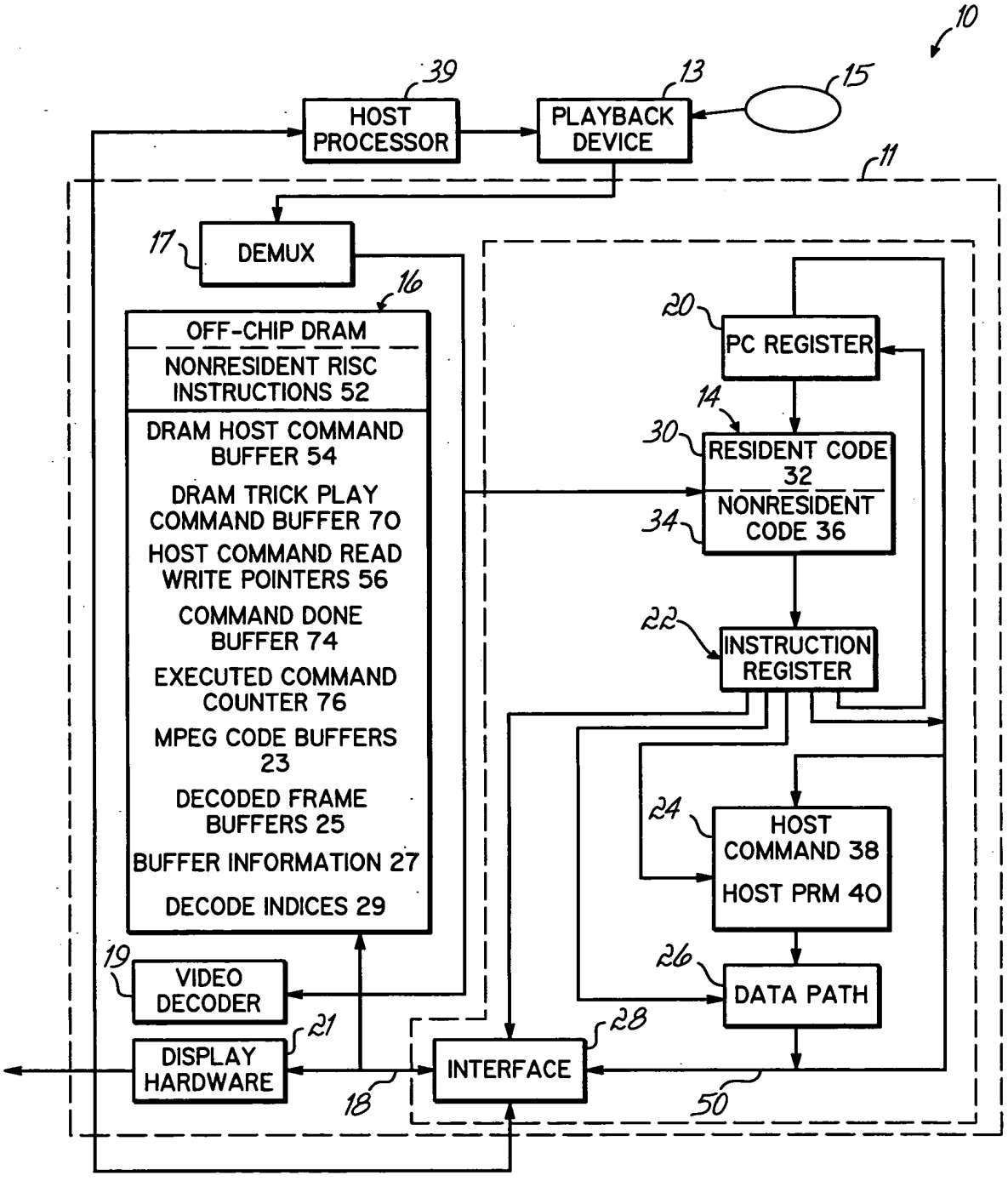
10
39
HOST PROCESSOR
13
PLAYBACK DEVICE
15
11
17
DEMUX
16
OFF-CHIP DRAM
NONRESIDENT RISC INSTRUCTIONS 52
DRAM HOST COMMAND BUFFER 54
DRAM TRICK PLAY COMMAND BUFFER 70
HOST COMMAND READ WRITE POINTERS 56
COMMAND DONE BUFFER 74
EXECUTED COMMAND COUNTER 76
MPEG CODE BUFFERS 23
DECODED FRAME BUFFERS 25
BUFFER INFORMATION 27
DECODE INDICES 29
20
PC REGISTER
14
30
RESIDENT CODE 32
NONRESIDENT CODE 36
34
22
INSTRUCTION REGISTER
24
HOST COMMAND 38
HOST PRM 40
26
DATA PATH
19
VIDEO DECODER
21
DISPLAY HARDWARE
28
INTERFACE
18
50

FIG. 1

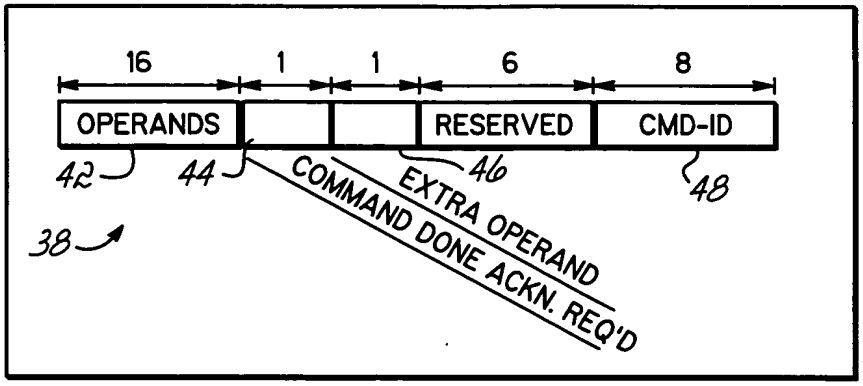

FIG. 2

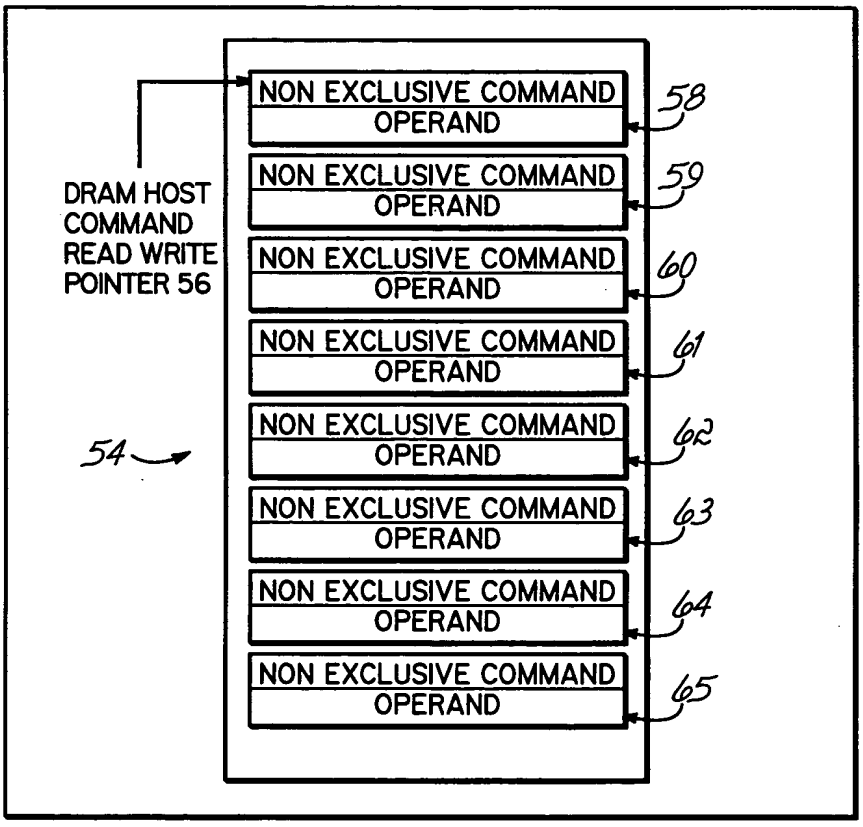

FIG. 3

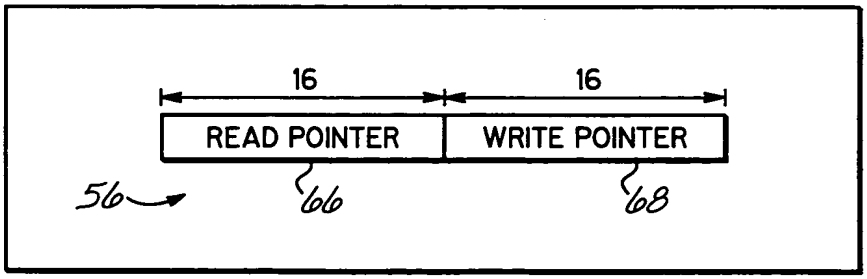

FIG. 4

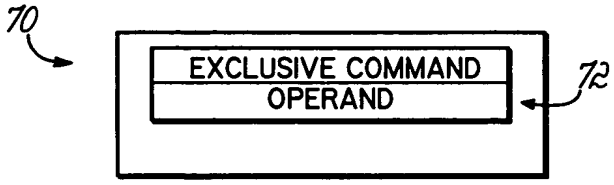

FIG. 5

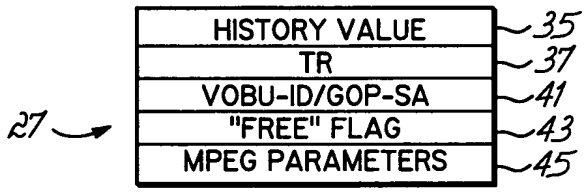

FIG. 6

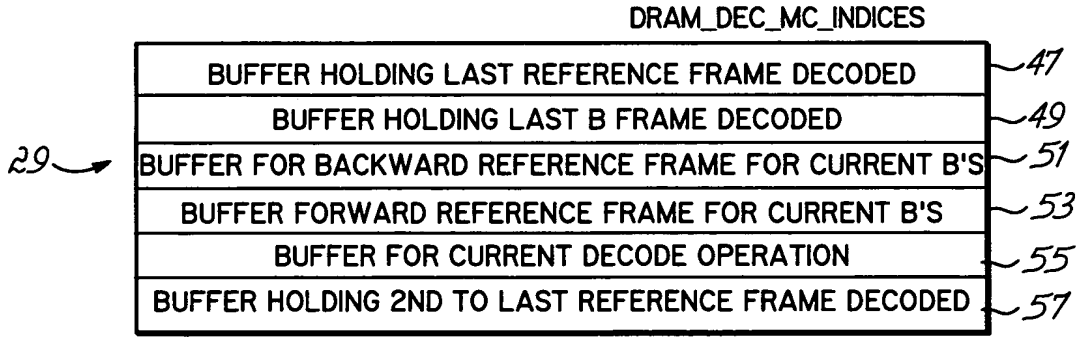

FIG. 7

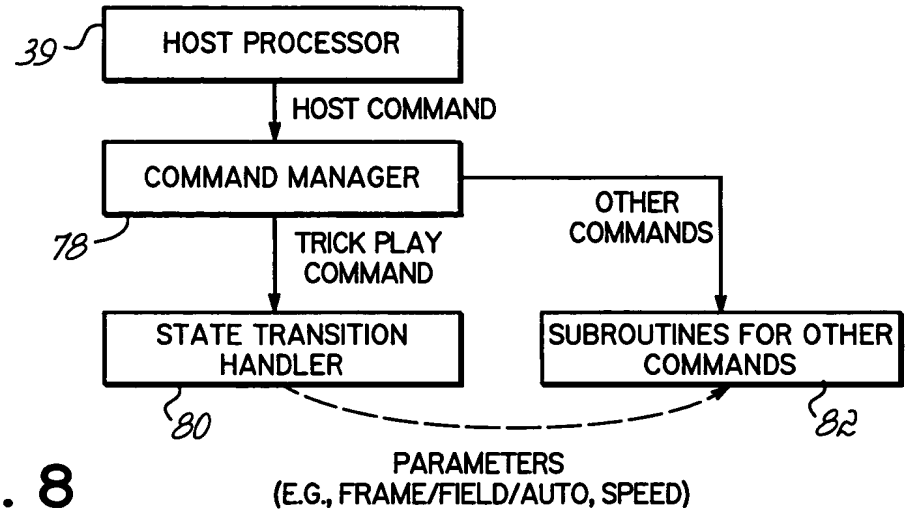

FIG. 8

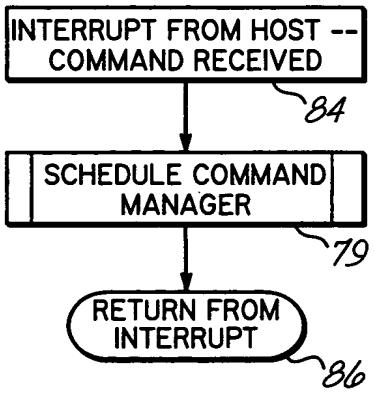

FIG. 9A

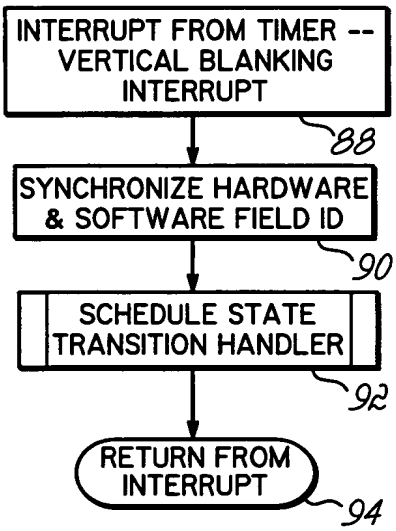

FIG. 9B

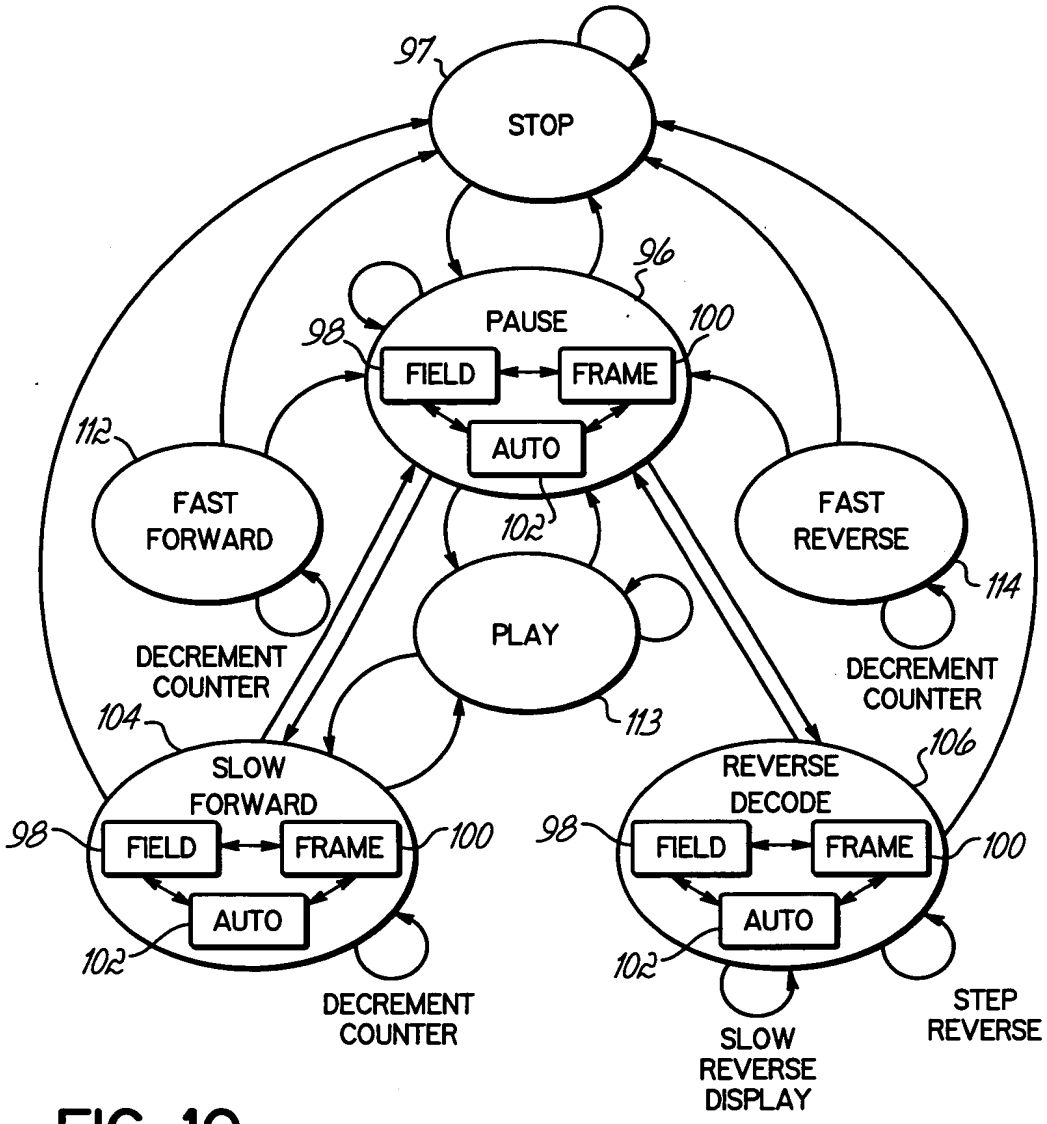
97
STOP
96
PAUSE
98
100
FIELD
FRAME
AUTO
112
FAST
FORWARD
102
FAST
REVERSE
114
PLAY
113
DECREMENT
COUNTER
DECREMENT
COUNTER
104
SLOW
FORWARD
106
REVERSE
DECODE
98
FIELD
FRAME
100
AUTO
102
DECREMENT
COUNTER
SLOW
REVERSE
DISPLAY
STEP
REVERSE

FIG. 10

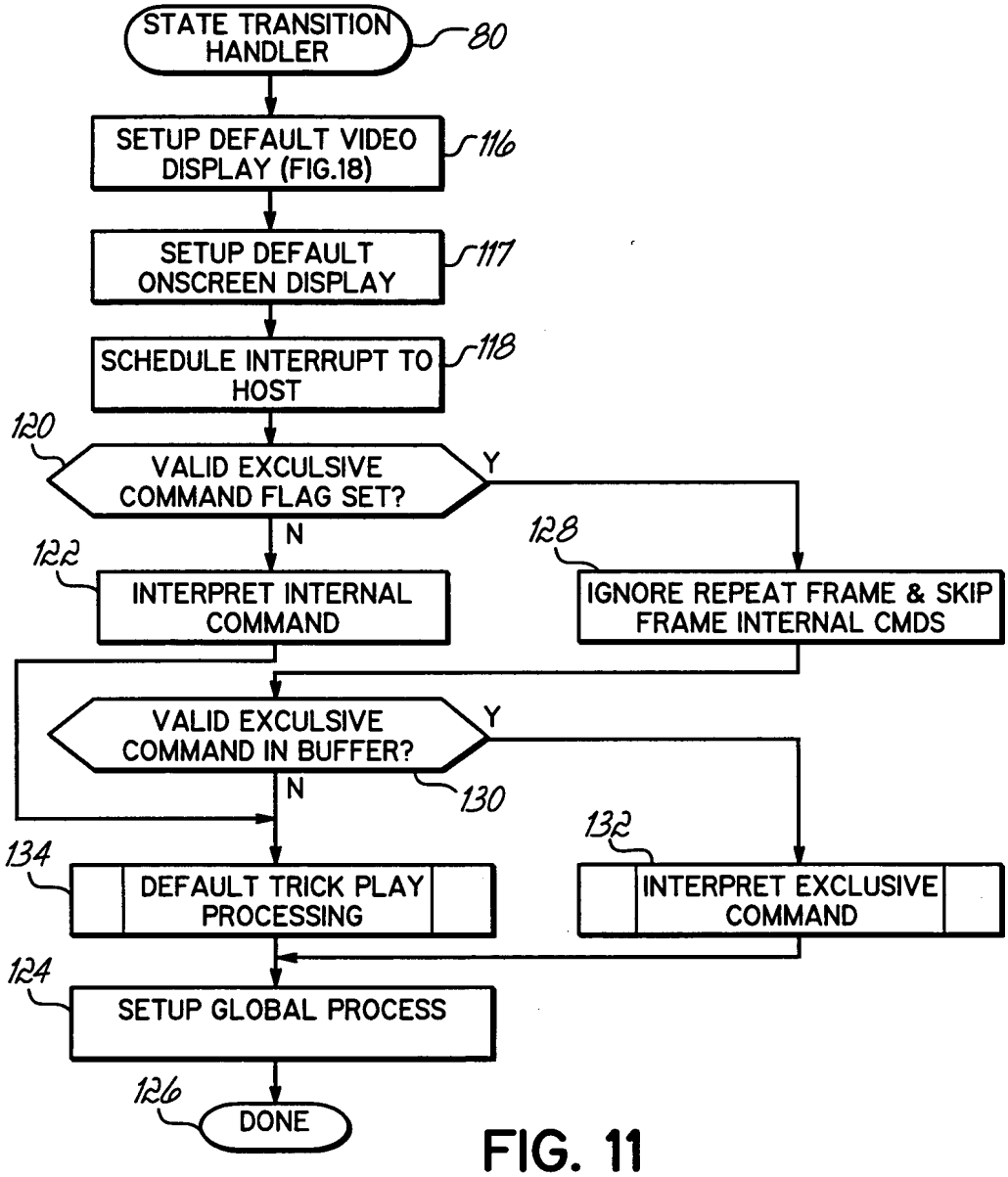
STATE TRANSITION HANDLER
80
SETUP DEFAULT VIDEO DISPLAY (FIG.18)
116
SETUP DEFAULT ONSCREEN DISPLAY
117
SCHEDULE INTERRUPT TO HOST
118
120
VALID EXCULSIVE COMMAND FLAG SET?
Y
N
122
INTERPRET INTERNAL COMMAND
128
IGNORE REPEAT FRAME & SKIP FRAME INTERNAL CMDS
VALID EXCULSIVE COMMAND IN BUFFER?
Y
N
130
132
134
DEFAULT TRICK PLAY PROCESSING
INTERPRET EXCLUSIVE COMMAND
124
SETUP GLOBAL PROCESS
126
DONE

FIG. 11

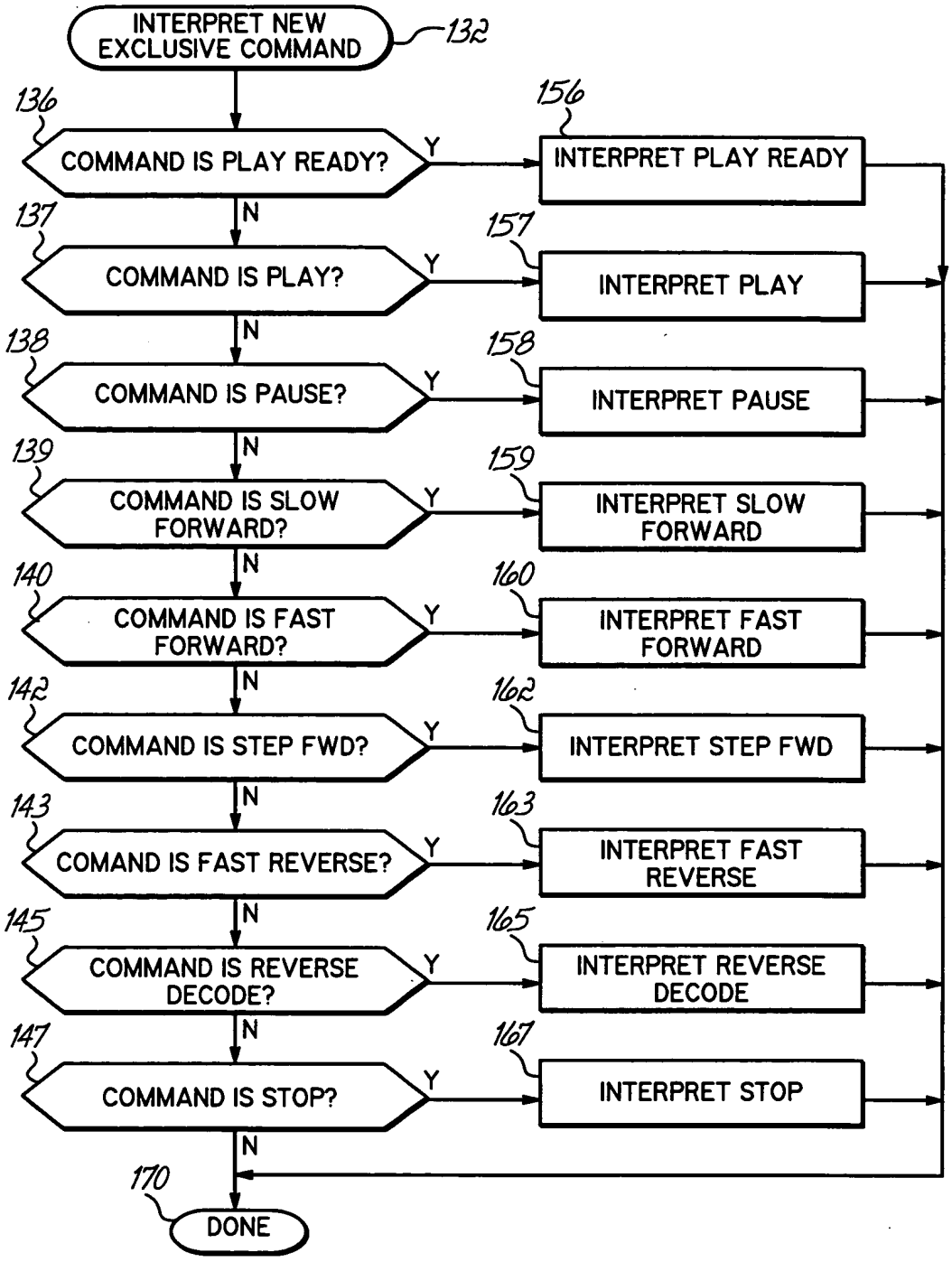
INTERPRET NEW EXCLUSIVE COMMAND
132
136
COMMAND IS PLAY READY?
Y
156
INTERPRET PLAY READY
N
137
COMMAND IS PLAY?
Y
157
INTERPRET PLAY
N
138
COMMAND IS PAUSE?
Y
158
INTERPRET PAUSE
N
139
COMMAND IS SLOW FORWARD?
Y
159
INTERPRET SLOW FORWARD
N
140
COMMAND IS FAST FORWARD?
Y
160
INTERPRET FAST FORWARD
N
142
COMMAND IS STEP FWD?
Y
162
INTERPRET STEP FWD
N
143
COMAND IS FAST REVERSE?
Y
163
INTERPRET FAST REVERSE
N
145
COMMAND IS REVERSE DECODE?
Y
165
INTERPRET REVERSE DECODE
N
147
COMMAND IS STOP?
Y
167
INTERPRET STOP
N
170
DONE

FIG. 12

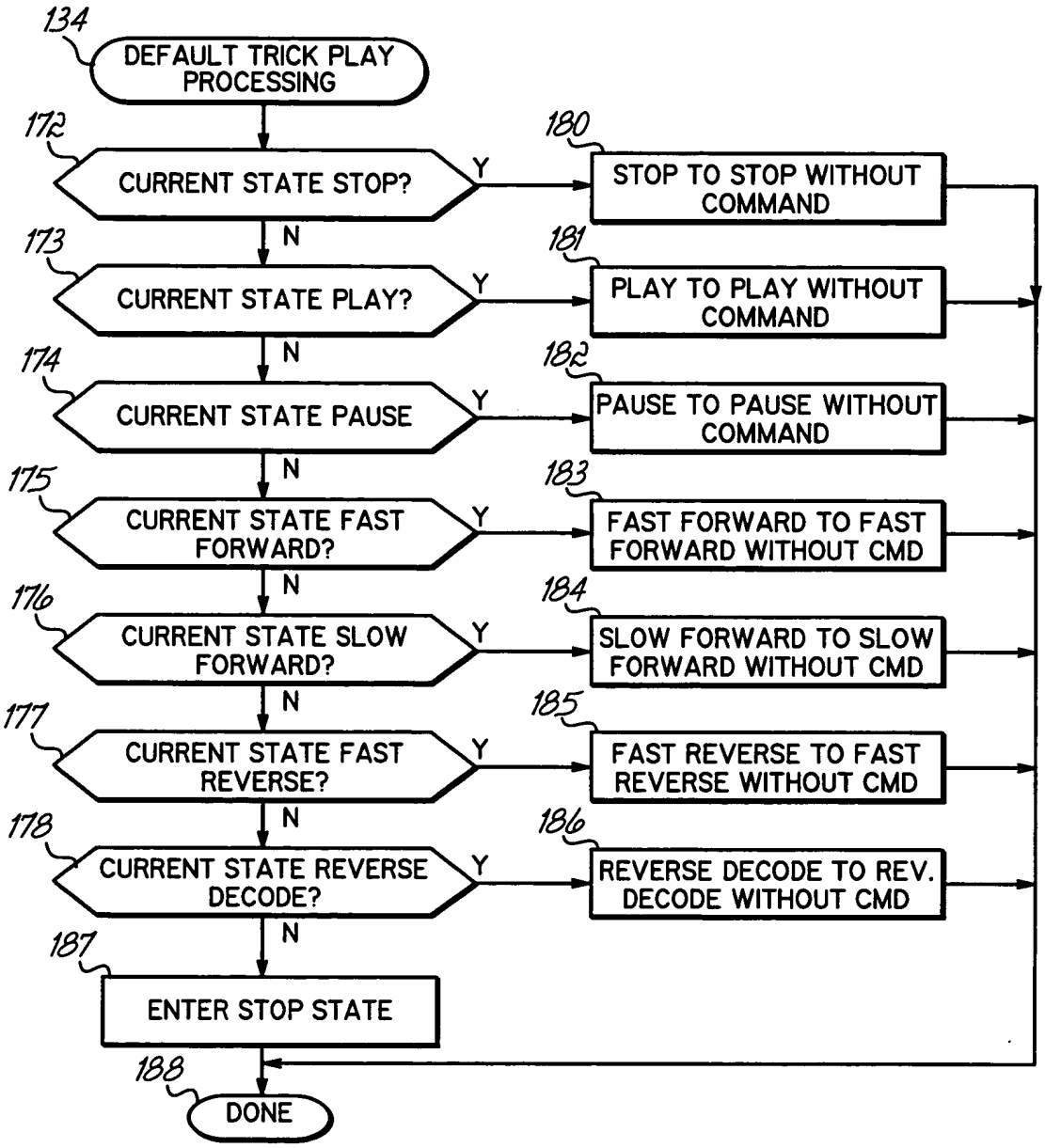
134
DEFAULT TRICK PLAY PROCESSING
172
CURRENT STATE STOP?
Y
180
STOP TO STOP WITHOUT COMMAND
N
173
CURRENT STATE PLAY?
Y
181
PLAY TO PLAY WITHOUT COMMAND
N
174
CURRENT STATE PAUSE
Y
182
PAUSE TO PAUSE WITHOUT COMMAND
N
175
CURRENT STATE FAST FORWARD?
Y
183
FAST FORWARD TO FAST FORWARD WITHOUT CMD
N
176
CURRENT STATE SLOW FORWARD?
Y
184
SLOW FORWARD TO SLOW FORWARD WITHOUT CMD
N
177
CURRENT STATE FAST REVERSE?
Y
185
FAST REVERSE TO FAST REVERSE WITHOUT CMD
N
178
CURRENT STATE REVERSE DECODE?
Y
186
REVERSE DECODE TO REV. DECODE WITHOUT CMD
N
187
ENTER STOP STATE
188
DONE

FIG. 13

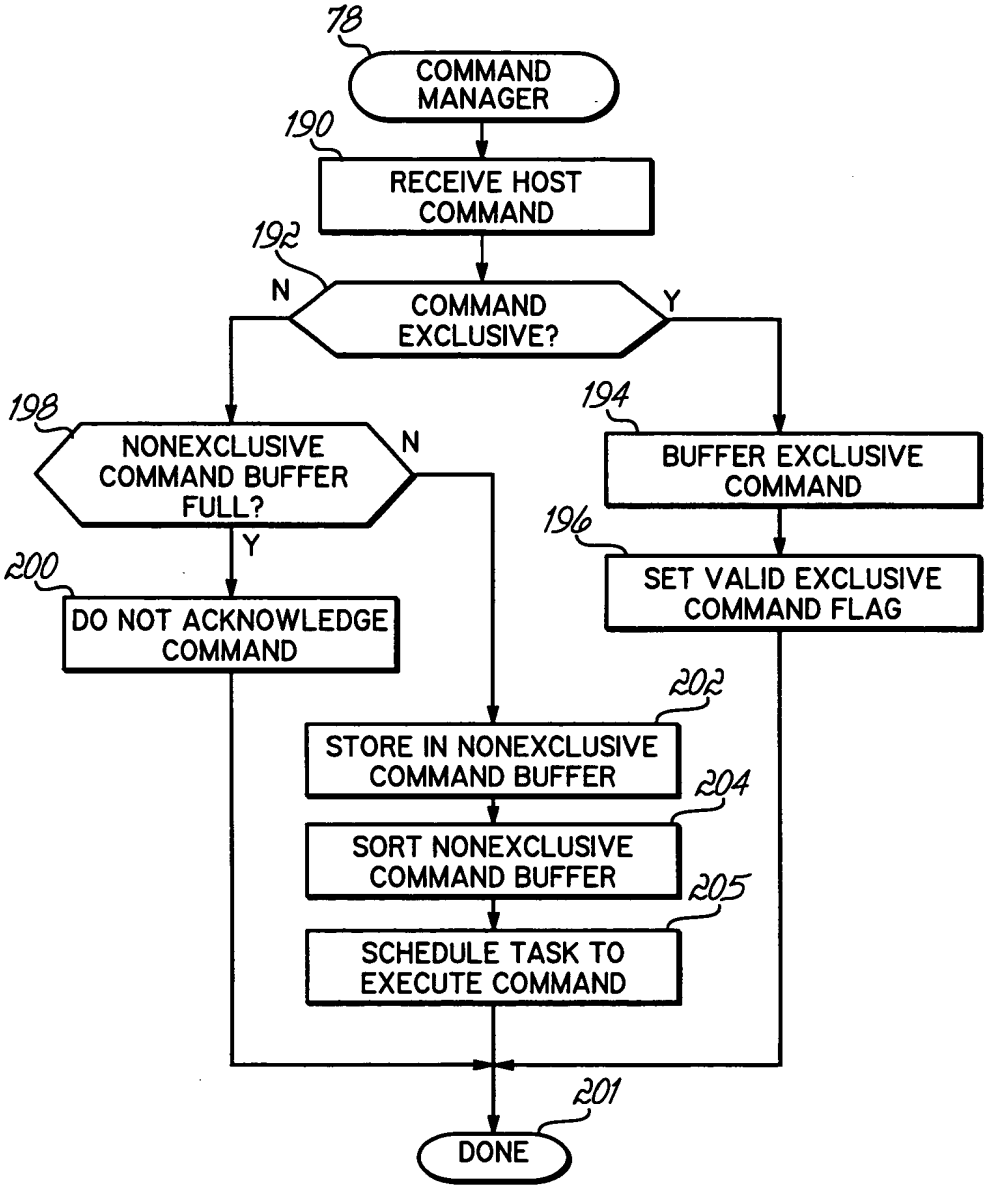
78
COMMAND MANAGER
190
RECEIVE HOST COMMAND
192
COMMAND EXCLUSIVE?
N
Y
198
NONEXCLUSIVE COMMAND BUFFER FULL?
N
Y
200
DO NOT ACKNOWLEDGE COMMAND
194
BUFFER EXCLUSIVE COMMAND
196
SET VALID EXCLUSIVE COMMAND FLAG
202
STORE IN NONEXCLUSIVE COMMAND BUFFER
204
SORT NONEXCLUSIVE COMMAND BUFFER
205
SCHEDULE TASK TO EXECUTE COMMAND
201
DONE

FIG. 14

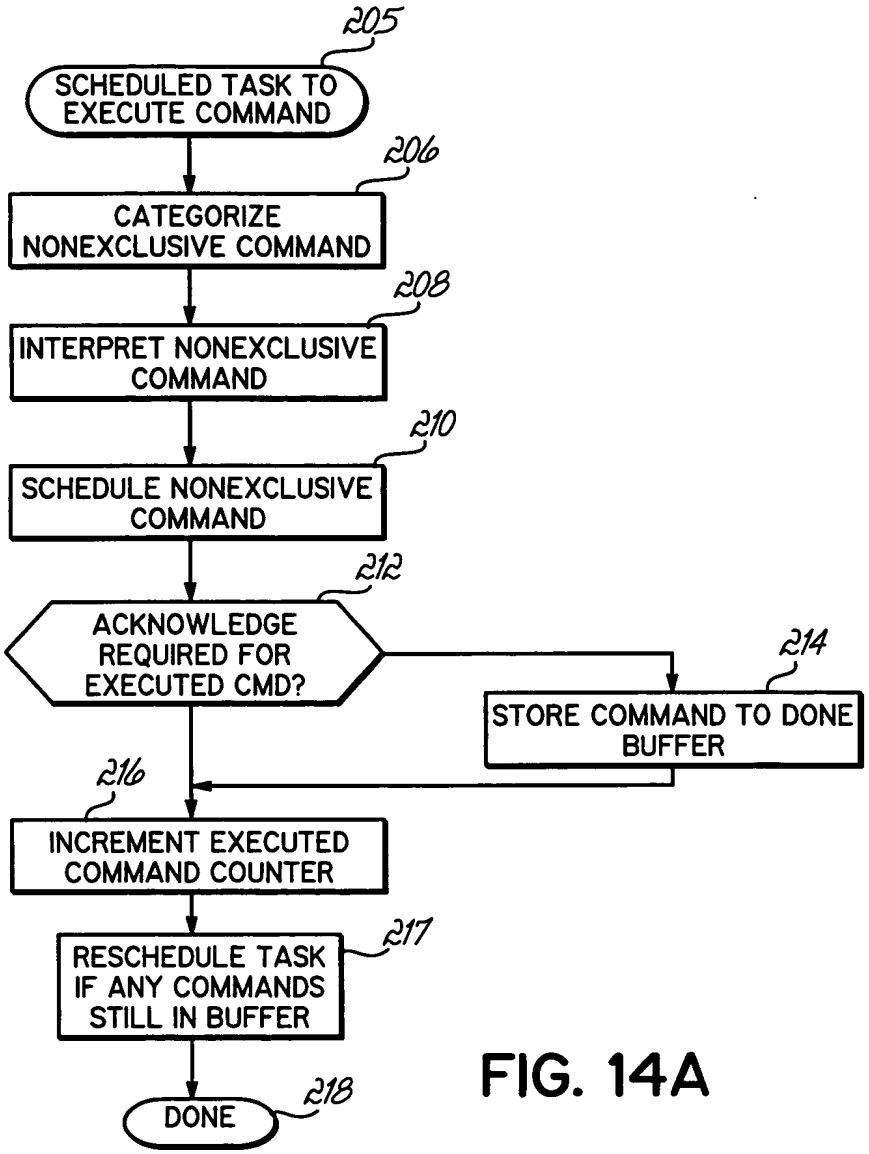
205
SCHEDULED TASK TO EXECUTE COMMAND
206
CATEGORIZE NONEXCLUSIVE COMMAND
208
INTERPRET NONEXCLUSIVE COMMAND
210
SCHEDULE NONEXCLUSIVE COMMAND
212
ACKNOWLEDGE REQUIRED FOR EXECUTED CMD?
214
STORE COMMAND TO DONE BUFFER
216
INCREMENT EXECUTED COMMAND COUNTER
217
RESCHEDULE TASK IF ANY COMMANDS STILL IN BUFFER
218
DONE

FIG. 14A

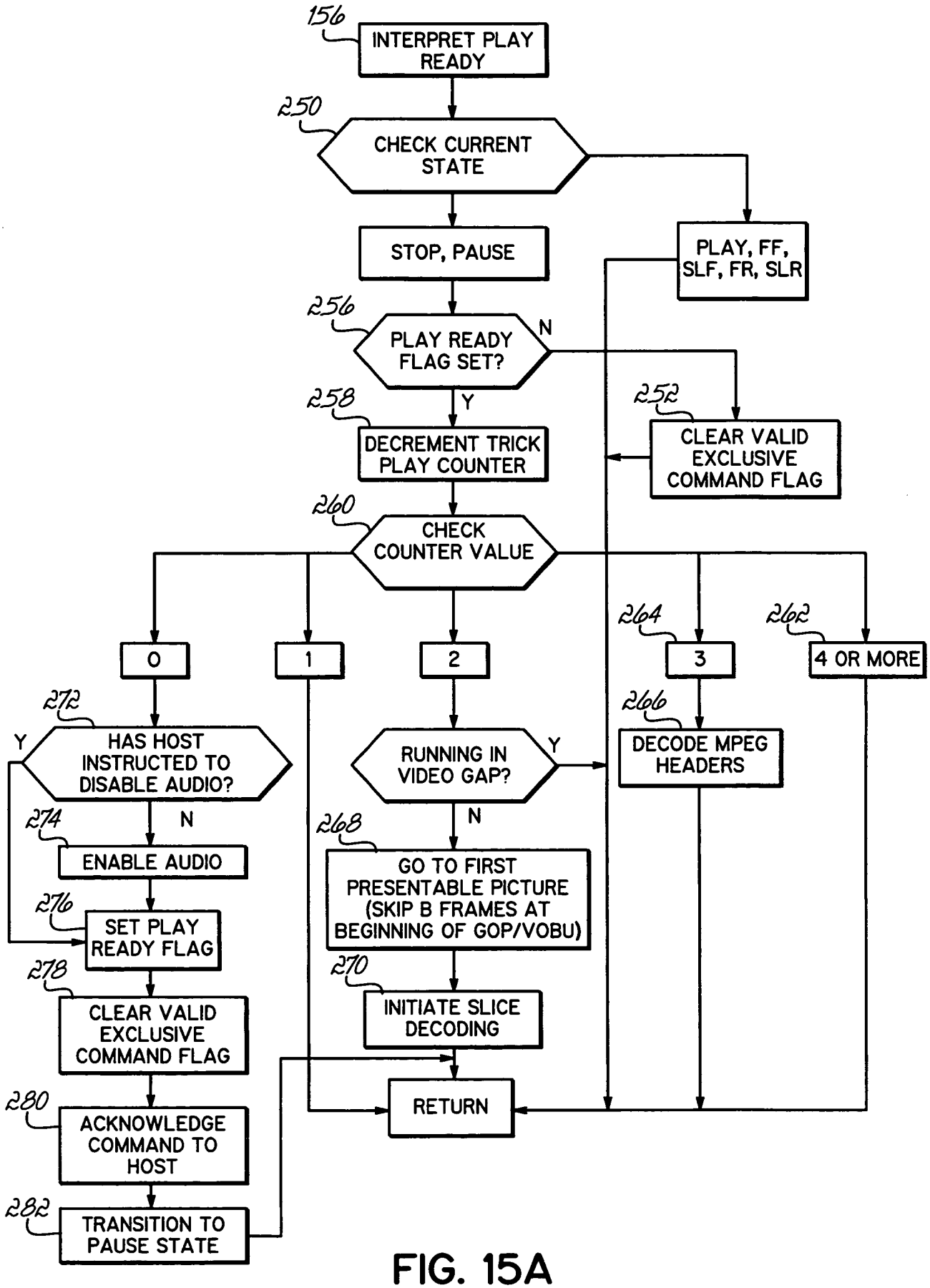
156
INTERPRET PLAY READY
250
CHECK CURRENT STATE
STOP, PAUSE
PLAY, FF, SLF, FR, SLR
256
PLAY READY FLAG SET?
N
Y
258
DECREMENT TRICK PLAY COUNTER
252
CLEAR VALID EXCLUSIVE COMMAND FLAG
260
CHECK COUNTER VALUE
0
1
2
3
4 OR MORE
264
262
272
HAS HOST INSTRUCTED TO DISABLE AUDIO?
Y
N
274
ENABLE AUDIO
276
SET PLAY READY FLAG
278
CLEAR VALID EXCLUSIVE COMMAND FLAG
280
ACKNOWLEDGE COMMAND TO HOST
282
TRANSITION TO PAUSE STATE
RUNNING IN VIDEO GAP?
Y
N
268
GO TO FIRST PRESENTABLE PICTURE (SKIP B FRAMES AT BEGINNING OF GOP/VOBU)
270
INITIATE SLICE DECODING
266
DECODE MPEG HEADERS
RETURN

FIG. 15A

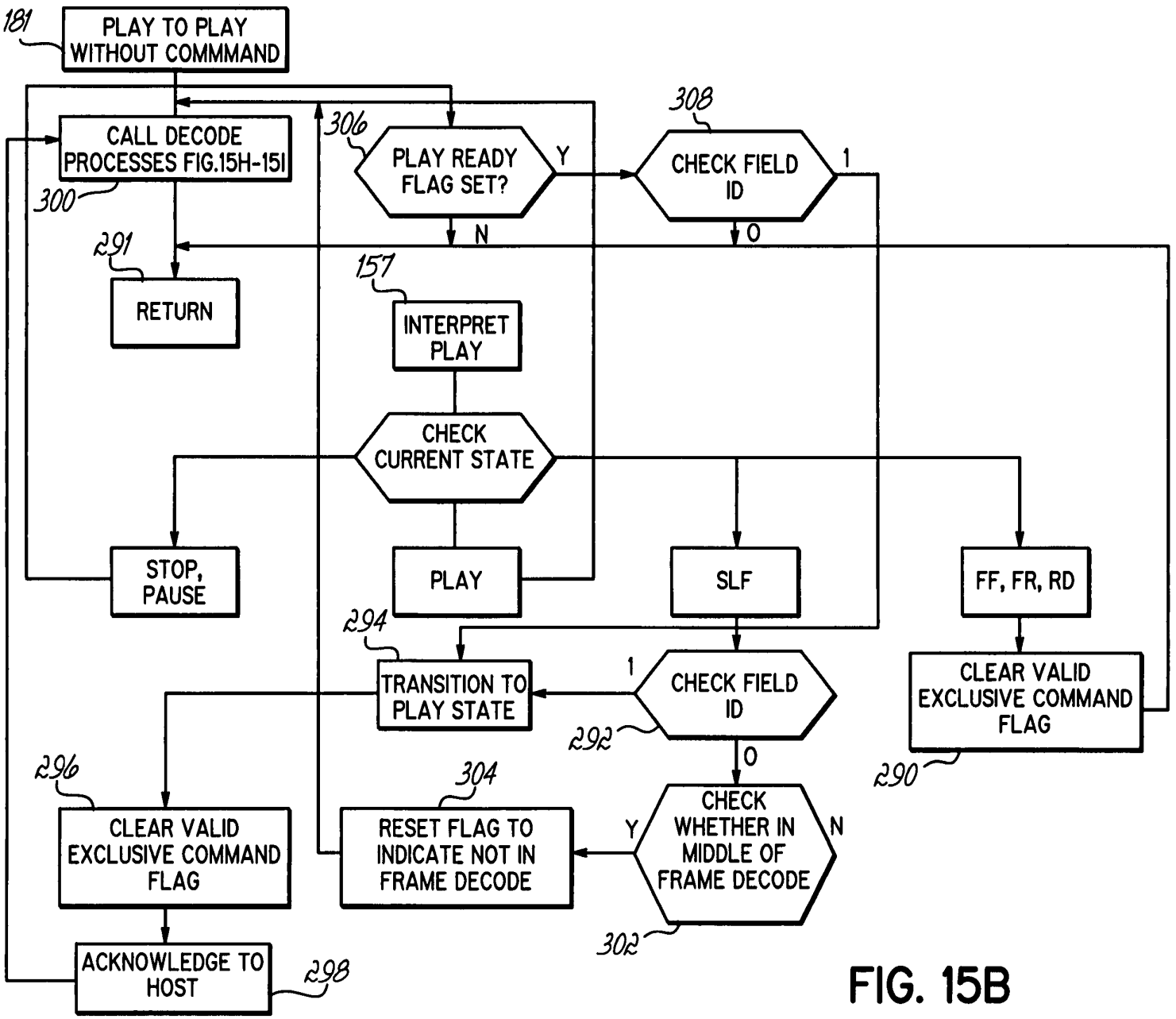
181
PLAY TO PLAY WITHOUT COMMMAND
CALL DECODE PROCESSES FIG.15H-15I
300
306
PLAY READY FLAG SET?
Y
N
308
CHECK FIELD ID
1
0
291
RETURN
157
INTERPRET PLAY
CHECK CURRENT STATE
STOP, PAUSE
PLAY
SLF
FF, FR, RD
294
TRANSITION TO PLAY STATE
1
CHECK FIELD ID
292
0
CLEAR VALID EXCLUSIVE COMMAND FLAG
290
296
CLEAR VALID EXCLUSIVE COMMAND FLAG
304
RESET FLAG TO INDICATE NOT IN FRAME DECODE
Y
CHECK WHETHER IN MIDDLE OF FRAME DECODE
N
302
ACKNOWLEDGE TO HOST
298

FIG. 15B

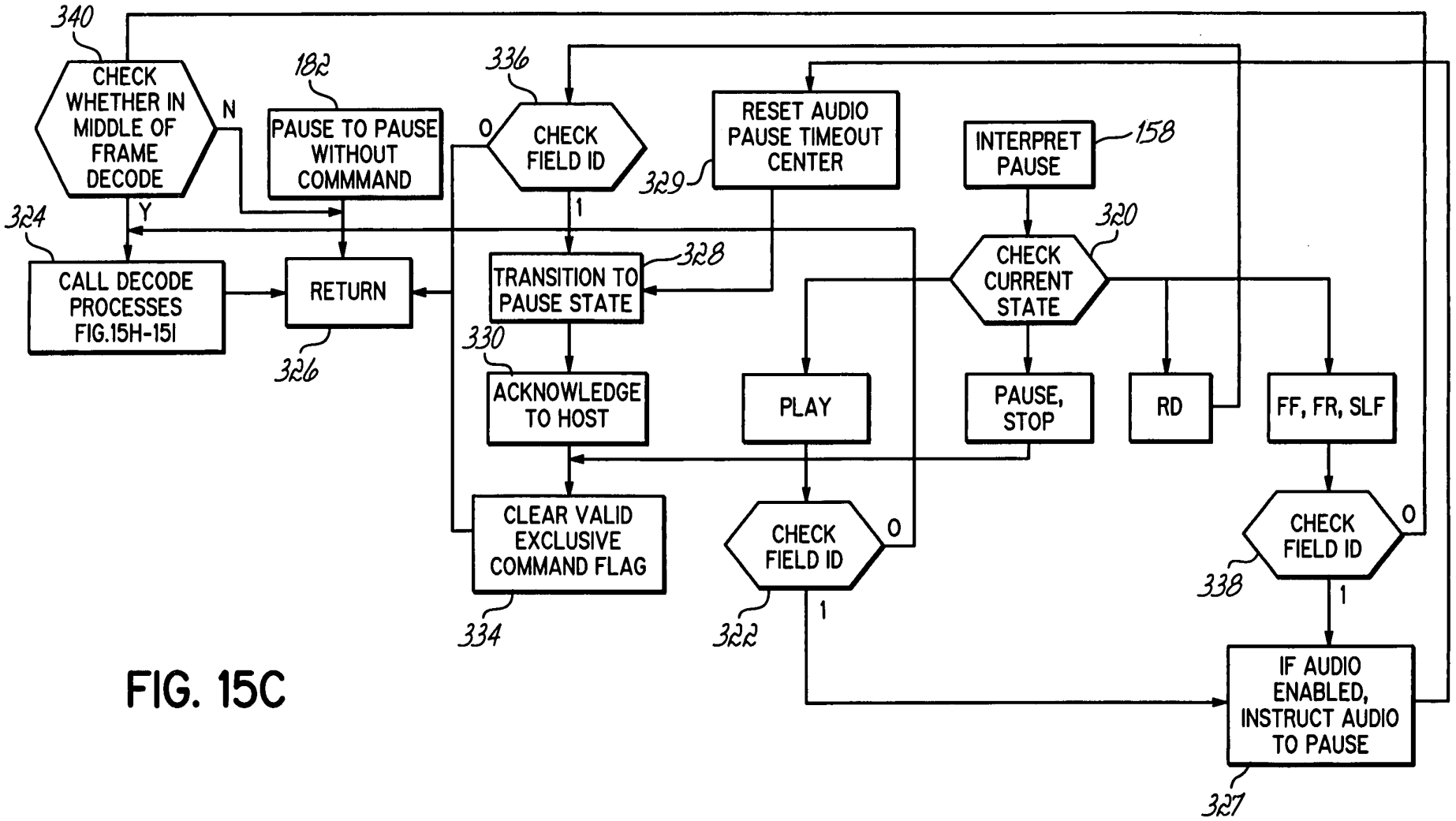
340
CHECK WHETHER IN MIDDLE OF FRAME DECODE
N
Y
182
PAUSE TO PAUSE WITHOUT COMMMAND
336
CHECK FIELD ID
0
1
329
RESET AUDIO PAUSE TIMEOUT CENTER
INTERPRET PAUSE
158
320
CHECK CURRENT STATE
324
CALL DECODE PROCESSES FIG.15H-15I
RETURN
326
TRANSITION TO PAUSE STATE
328
330
ACKNOWLEDGE TO HOST
PLAY
PAUSE, STOP
RD
FF, FR, SLF
CLEAR VALID EXCLUSIVE COMMAND FLAG
334
CHECK FIELD ID
322
CHECK FIELD ID
338
IF AUDIO ENABLED, INSTRUCT AUDIO TO PAUSE
327

FIG. 15C

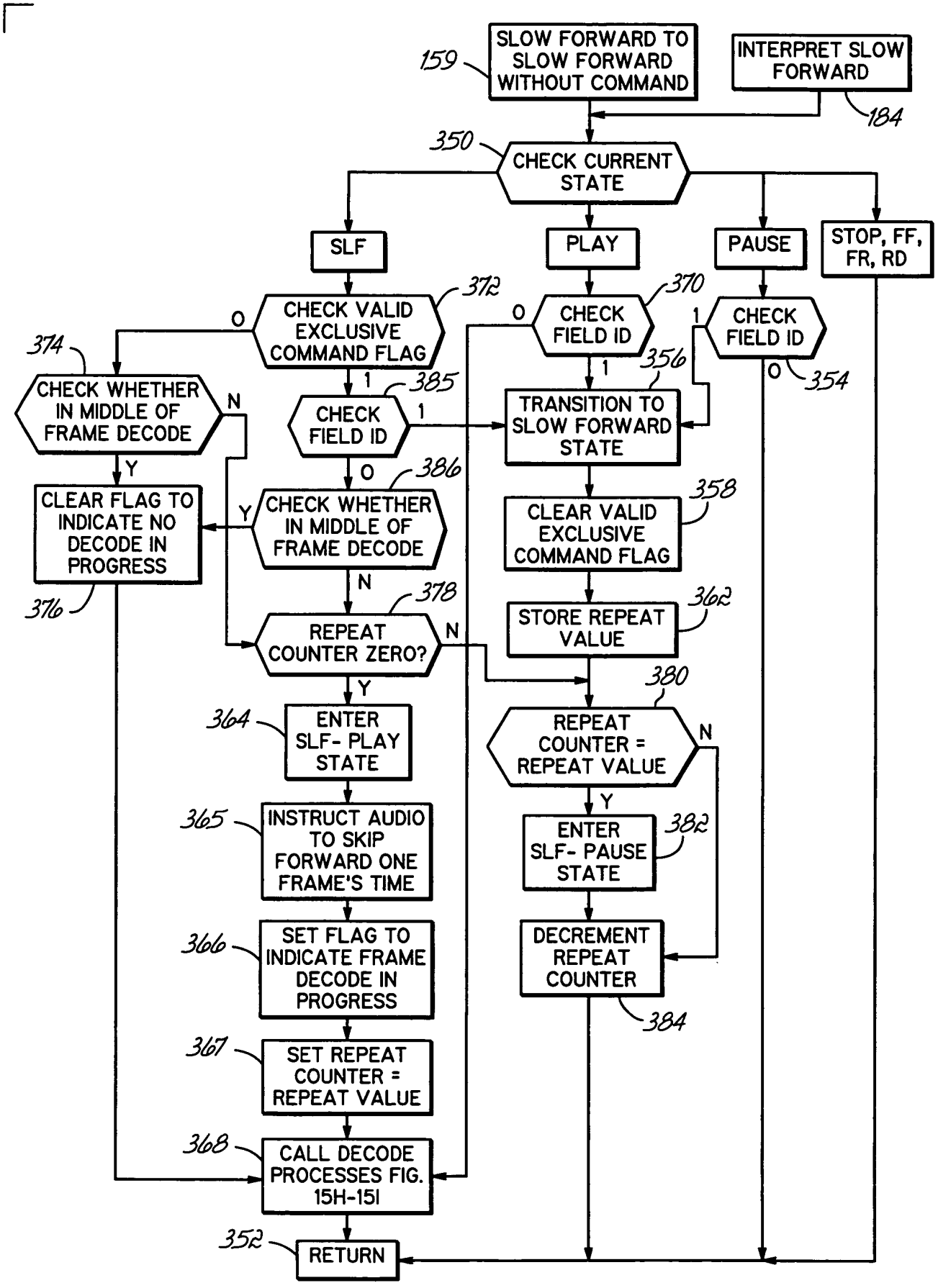
159
SLOW FORWARD TO SLOW FORWARD WITHOUT COMMAND
INTERPRET SLOW FORWARD
184
350
CHECK CURRENT STATE
SLF
PLAY
PAUSE
STOP, FF, FR, RD
372
CHECK VALID EXCLUSIVE COMMAND FLAG
370
CHECK FIELD ID
CHECK FIELD ID
354
374
CHECK WHETHER IN MIDDLE OF FRAME DECODE
385
CHECK FIELD ID
356
TRANSITION TO SLOW FORWARD STATE
386
CHECK WHETHER IN MIDDLE OF FRAME DECODE
358
CLEAR VALID EXCLUSIVE COMMAND FLAG
CLEAR FLAG TO INDICATE NO DECODE IN PROGRESS
376
378
REPEAT COUNTER ZERO?
362
STORE REPEAT VALUE
380
REPEAT COUNTER = REPEAT VALUE
364
ENTER SLF- PLAY STATE
365
INSTRUCT AUDIO TO SKIP FORWARD ONE FRAME'S TIME
382
ENTER SLF- PAUSE STATE
366
SET FLAG TO INDICATE FRAME DECODE IN PROGRESS
DECREMENT REPEAT COUNTER
384
367
SET REPEAT COUNTER = REPEAT VALUE
368
CALL DECODE PROCESSES FIG. 15H-15I
352
RETURN

FIG. 15D

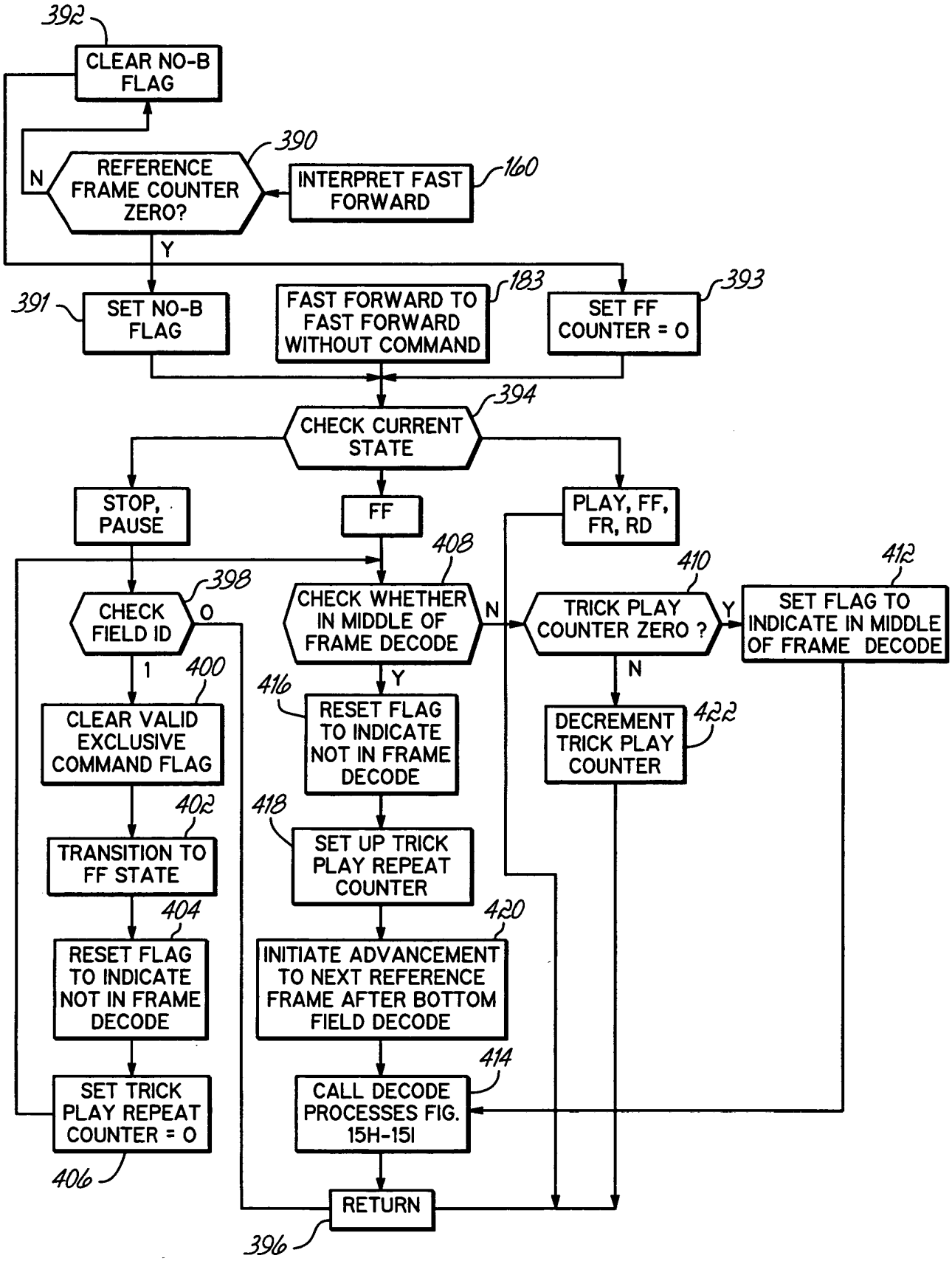
392
CLEAR NO-B FLAG
390
N
REFERENCE FRAME COUNTER ZERO?
INTERPRET FAST FORWARD
160
Y
391
SET NO-B FLAG
FAST FORWARD TO FAST FORWARD WITHOUT COMMAND
183
SET FF COUNTER = 0
393
394
CHECK CURRENT STATE
STOP, PAUSE
FF
PLAY, FF, FR, RD
408
410
412
398
CHECK FIELD ID
0
CHECK WHETHER IN MIDDLE OF FRAME DECODE
N
TRICK PLAY COUNTER ZERO ?
Y
SET FLAG TO INDICATE IN MIDDLE OF FRAME DECODE
1
400
Y
N
416
RESET FLAG TO INDICATE NOT IN FRAME DECODE
DECREMENT TRICK PLAY COUNTER
422
CLEAR VALID EXCLUSIVE COMMAND FLAG
402
418
TRANSITION TO FF STATE
SET UP TRICK PLAY REPEAT COUNTER
404
420
RESET FLAG TO INDICATE NOT IN FRAME DECODE
INITIATE ADVANCEMENT TO NEXT REFERENCE FRAME AFTER BOTTOM FIELD DECODE
414
SET TRICK PLAY REPEAT COUNTER = 0
CALL DECODE PROCESSES FIG. 15H-15I
406
RETURN
396

FIG. 15E

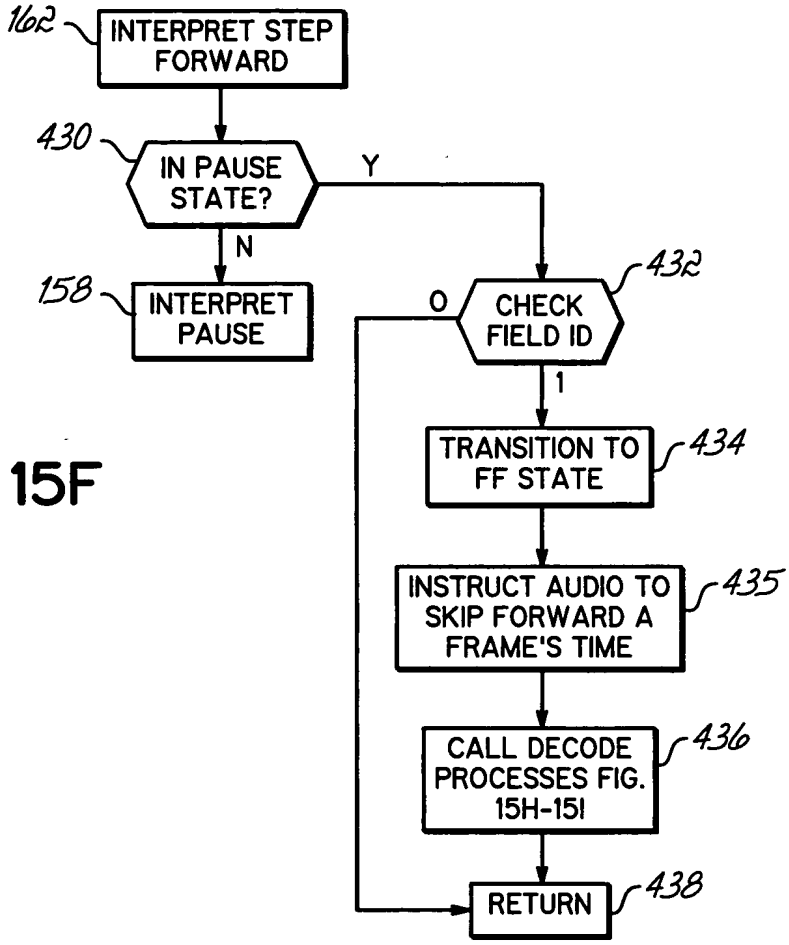
162
INTERPRET STEP FORWARD
430
IN PAUSE STATE?
Y
N
158
INTERPRET PAUSE
0
CHECK FIELD ID
432
1
TRANSITION TO FF STATE
434
INSTRUCT AUDIO TO SKIP FORWARD A FRAME'S TIME
435
CALL DECODE PROCESSES FIG. 15H-15I
436
RETURN
438

FIG. 15F

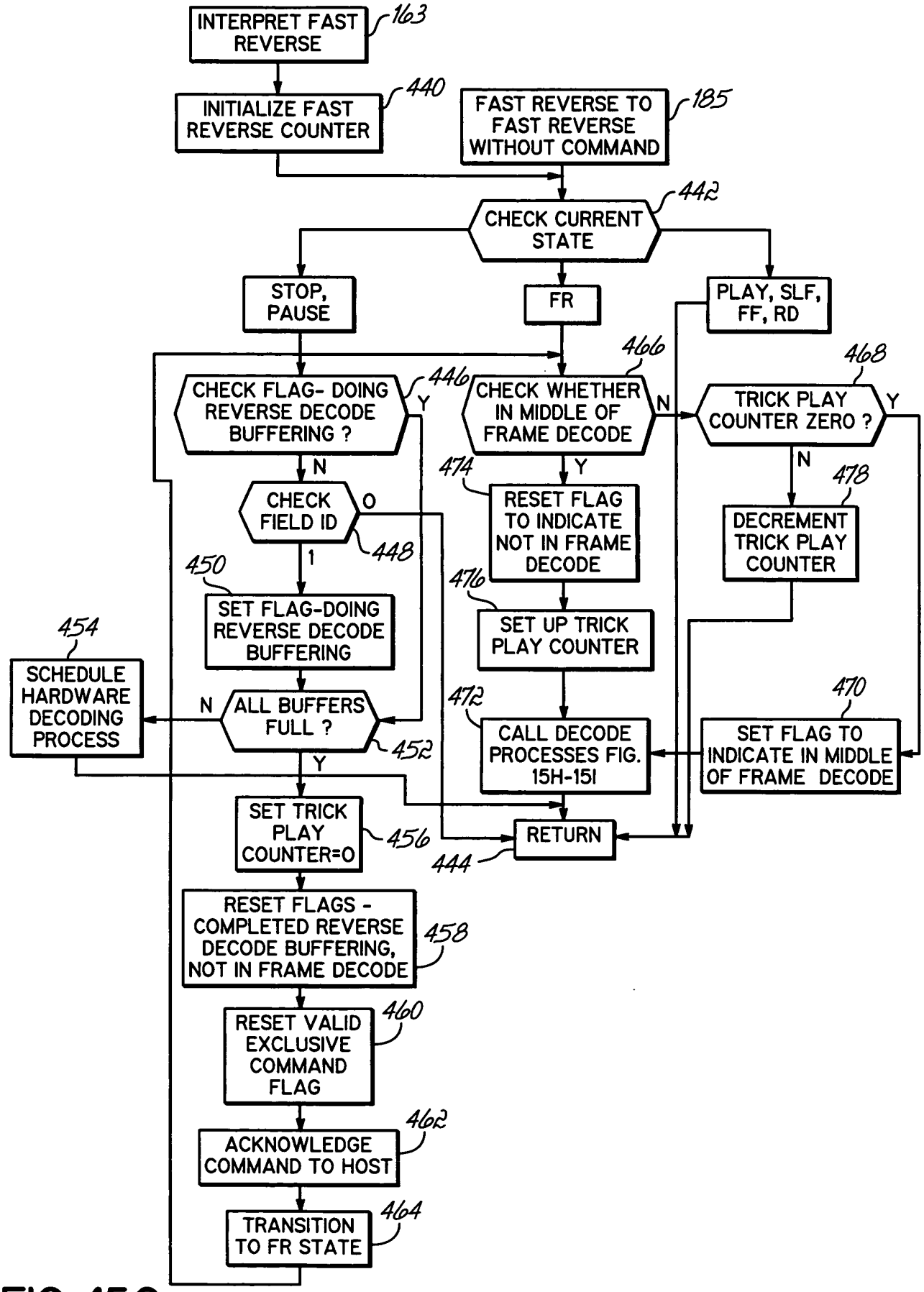
INTERPRET FAST REVERSE
163
INITIALIZE FAST REVERSE COUNTER
440
FAST REVERSE TO FAST REVERSE WITHOUT COMMAND
185
CHECK CURRENT STATE
442
STOP, PAUSE
FR
PLAY, SLF, FF, RD
CHECK FLAG- DOING REVERSE DECODE BUFFERING ?
446
Y
N
CHECK WHETHER IN MIDDLE OF FRAME DECODE
466
N
Y
TRICK PLAY COUNTER ZERO ?
468
Y
N
CHECK FIELD ID
O
1
448
450
SET FLAG-DOING REVERSE DECODE BUFFERING
454
SCHEDULE HARDWARE DECODING PROCESS
N
ALL BUFFERS FULL ?
452
Y
474
RESET FLAG TO INDICATE NOT IN FRAME DECODE
476
SET UP TRICK PLAY COUNTER
472
CALL DECODE PROCESSES FIG. 15H-15I
478
DECREMENT TRICK PLAY COUNTER
470
SET FLAG TO INDICATE IN MIDDLE OF FRAME DECODE
SET TRICK PLAY COUNTER=0
456
RETURN
444
RESET FLAGS - COMPLETED REVERSE DECODE BUFFERING, NOT IN FRAME DECODE
458
RESET VALID EXCLUSIVE COMMAND FLAG
460
ACKNOWLEDGE COMMAND TO HOST
462
TRANSITION TO FR STATE
464

FIG. 15G

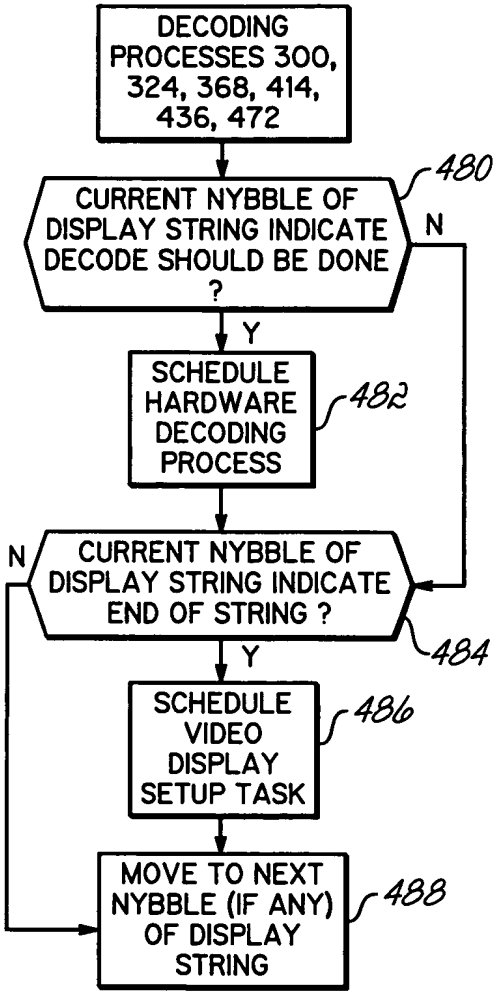

FIG. 15H

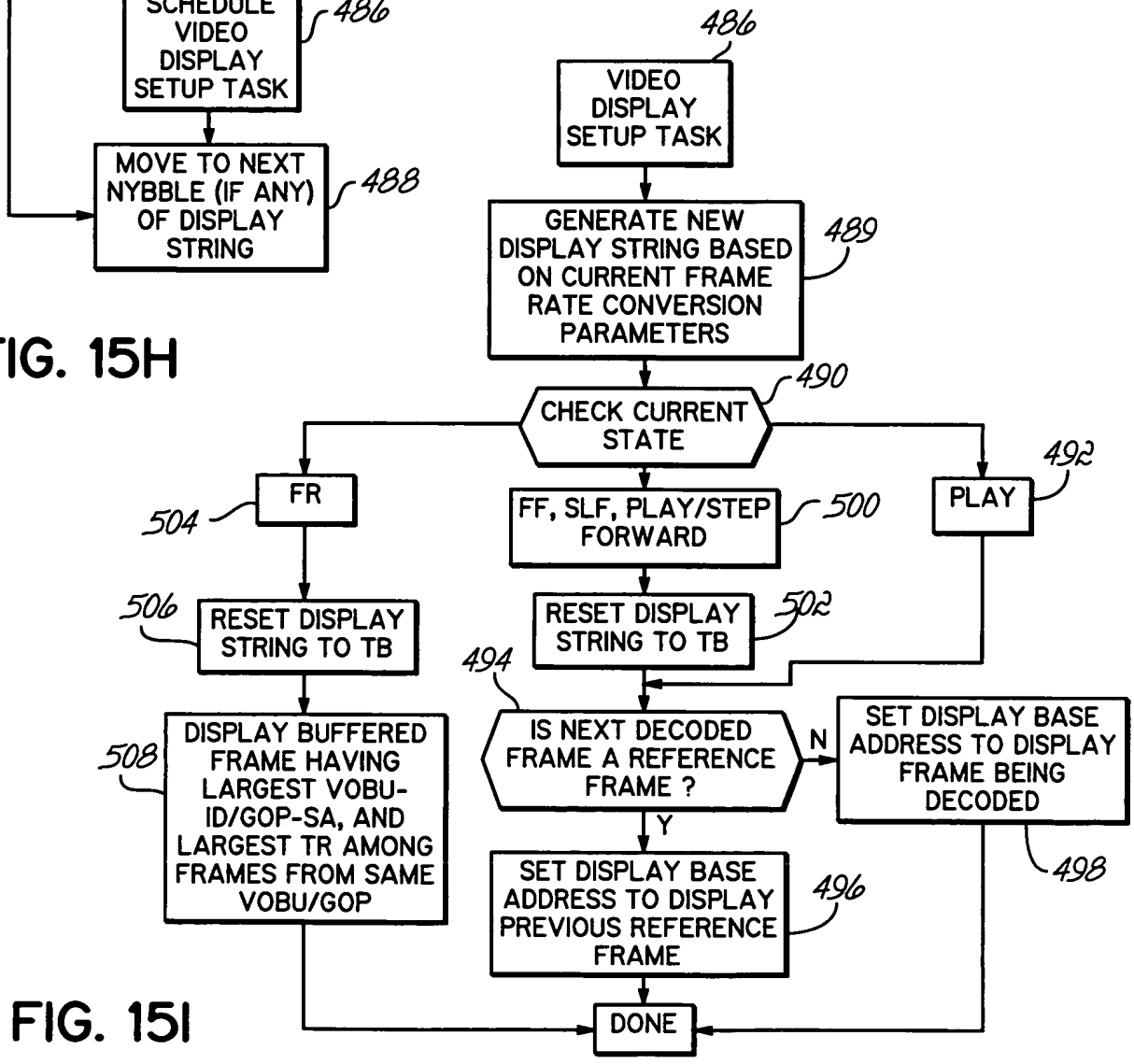

FIG. 15I

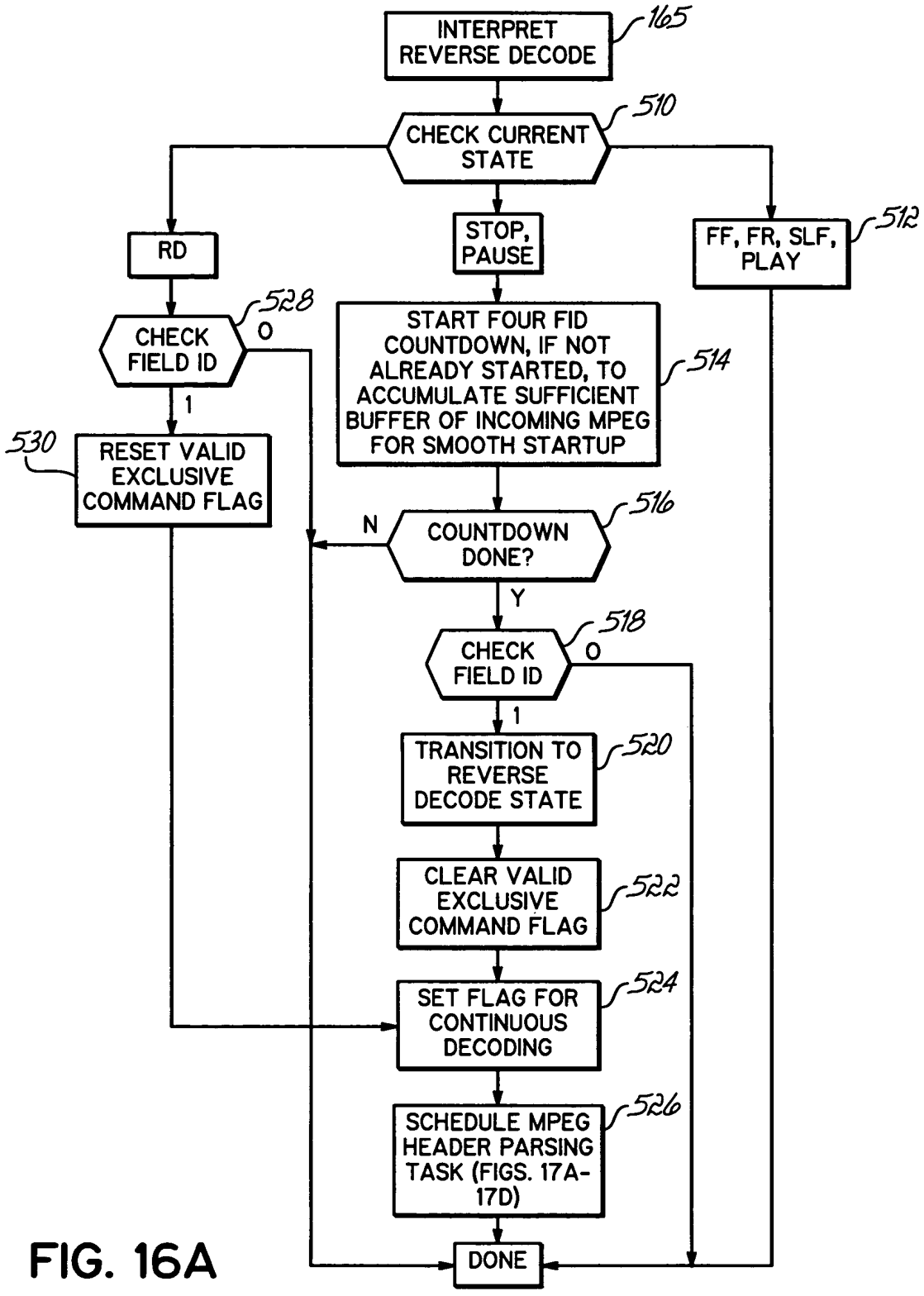
INTERPRET REVERSE DECODE
165
CHECK CURRENT STATE
510
RD
STOP, PAUSE
FF, FR, SLF, PLAY
512
CHECK FIELD ID
528
0
1
START FOUR FID COUNTDOWN, IF NOT ALREADY STARTED, TO ACCUMULATE SUFFICIENT BUFFER OF INCOMING MPEG FOR SMOOTH STARTUP
514
530
RESET VALID EXCLUSIVE COMMAND FLAG
N
COUNTDOWN DONE?
516
Y
CHECK FIELD ID
518
0
1
TRANSITION TO REVERSE DECODE STATE
520
CLEAR VALID EXCLUSIVE COMMAND FLAG
522
SET FLAG FOR CONTINUOUS DECODING
524
SCHEDULE MPEG HEADER PARSING TASK (FIGS. 17A-17D)
526
DONE

FIG. 16A

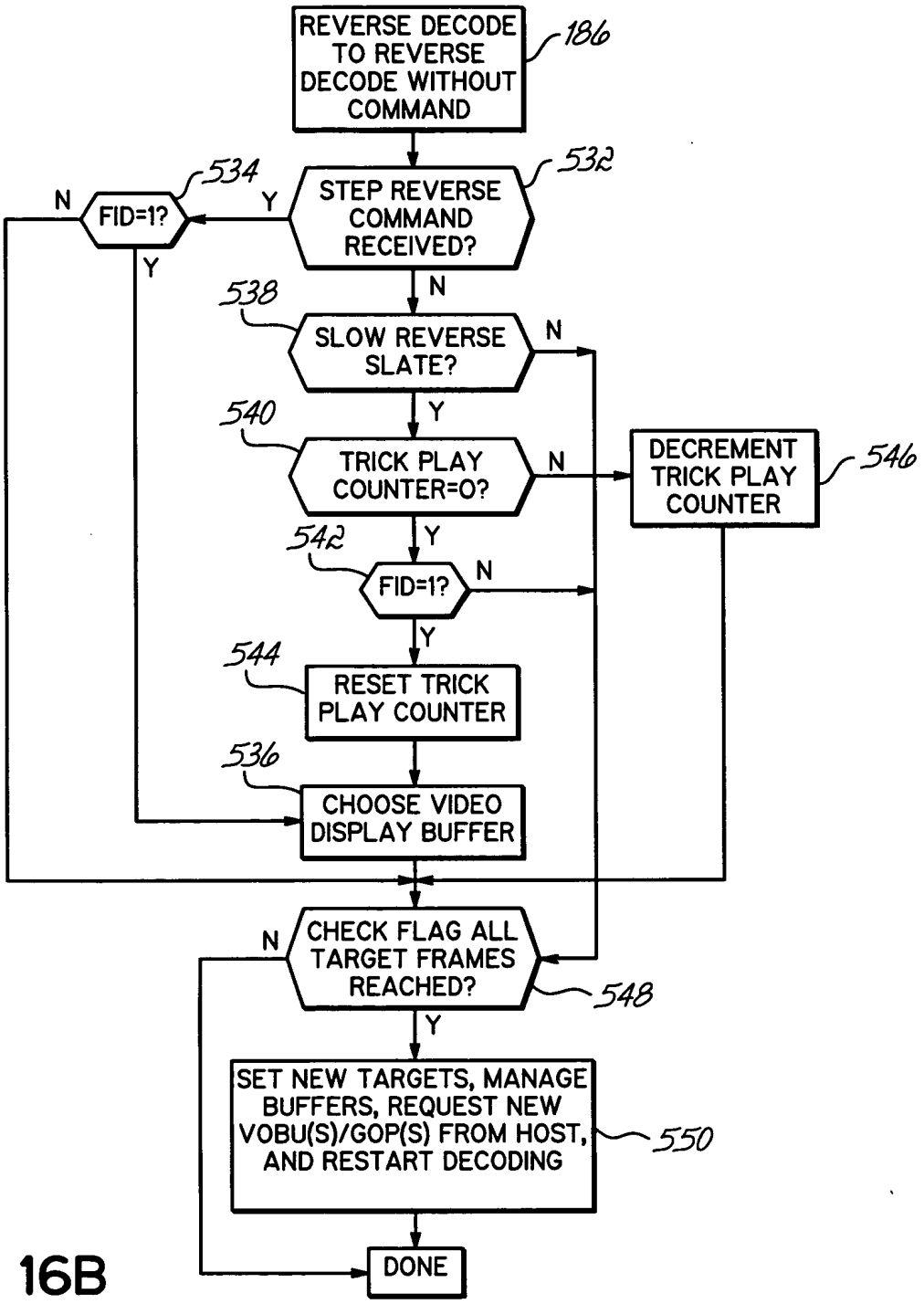
REVERSE DECODE TO REVERSE DECODE WITHOUT COMMAND
186
STEP REVERSE COMMAND RECEIVED?
532
FID=1?
534
N
Y
Y
N
SLOW REVERSE SLATE?
538
N
Y
TRICK PLAY COUNTER=0?
540
N
DECREMENT TRICK PLAY COUNTER
546
Y
FID=1?
542
N
Y
RESET TRICK PLAY COUNTER
544
CHOOSE VIDEO DISPLAY BUFFER
536
CHECK FLAG ALL TARGET FRAMES REACHED?
548
N
Y
SET NEW TARGETS, MANAGE BUFFERS, REQUEST NEW VOBU(S)/GOP(S) FROM HOST, AND RESTART DECODING
550
DONE

FIG. 16B

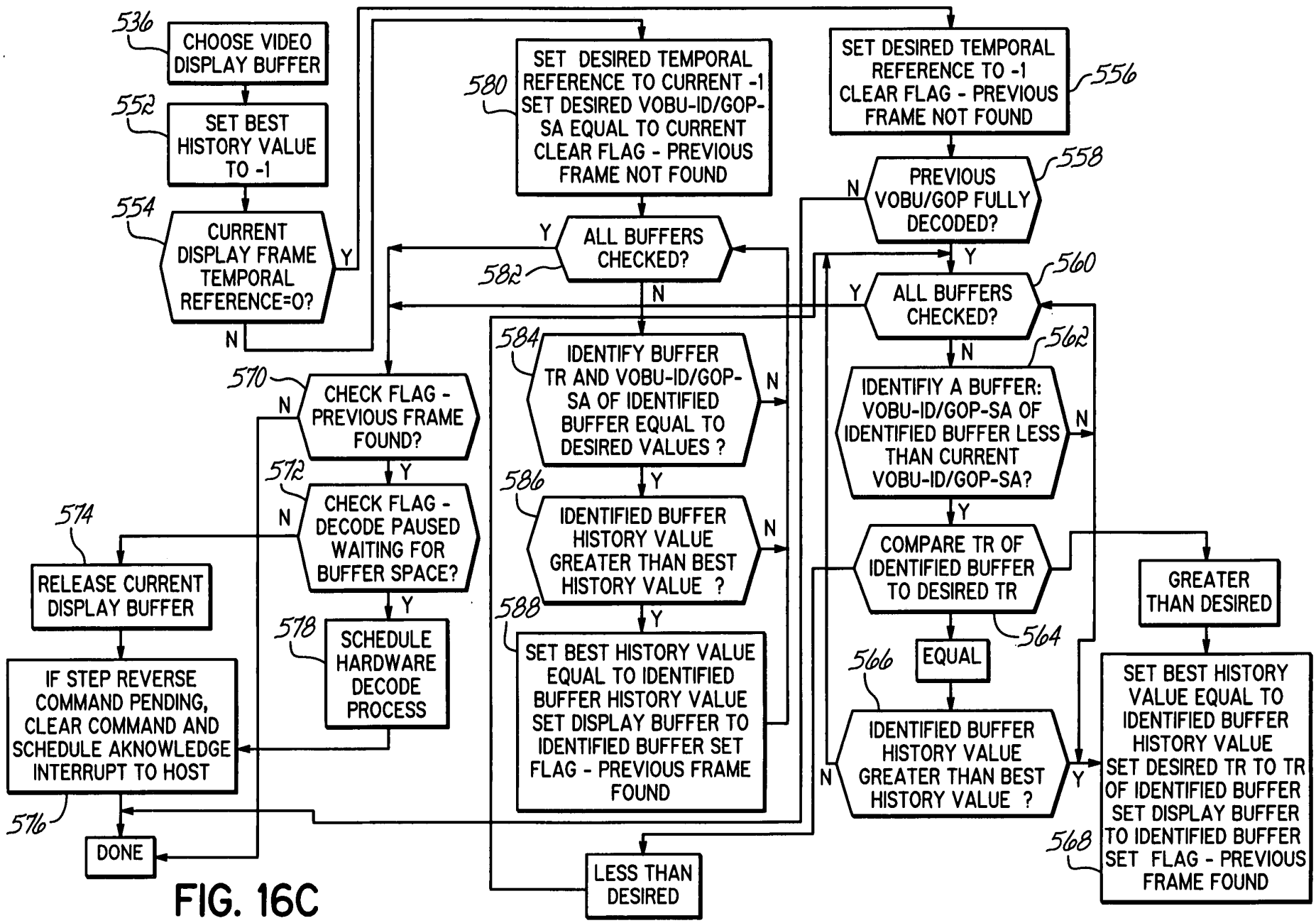
536
CHOOSE VIDEO DISPLAY BUFFER
552
SET BEST HISTORY VALUE TO -1
554
CURRENT DISPLAY FRAME TEMPORAL REFERENCE=0?
Y
N
580
SET DESIRED TEMPORAL REFERENCE TO CURRENT -1 SET DESIRED VOBU-ID/GOP-SA EQUAL TO CURRENT CLEAR FLAG - PREVIOUS FRAME NOT FOUND
Y
ALL BUFFERS CHECKED?
582
N
556
SET DESIRED TEMPORAL REFERENCE TO -1 CLEAR FLAG - PREVIOUS FRAME NOT FOUND
558
N
PREVIOUS VOBU/GOP FULLY DECODED?
Y
560
Y
ALL BUFFERS CHECKED?
N
562
IDENTIFIY A BUFFER: VOBU-ID/GOP-SA OF IDENTIFIED BUFFER LESS THAN CURRENT VOBU-ID/GOP-SA?
N
Y
564
COMPARE TR OF IDENTIFIED BUFFER TO DESIRED TR
GREATER THAN DESIRED
EQUAL
566
IDENTIFIED BUFFER HISTORY VALUE GREATER THAN BEST HISTORY VALUE ?
N
Y
568
SET BEST HISTORY VALUE EQUAL TO IDENTIFIED BUFFER HISTORY VALUE SET DESIRED TR TO TR OF IDENTIFIED BUFFER SET DISPLAY BUFFER TO IDENTIFIED BUFFER SET FLAG - PREVIOUS FRAME FOUND
584
IDENTIFY BUFFER TR AND VOBU-ID/GOP-SA OF IDENTIFIED BUFFER EQUAL TO DESIRED VALUES ?
N
Y
586
IDENTIFIED BUFFER HISTORY VALUE GREATER THAN BEST HISTORY VALUE ?
N
Y
588
SET BEST HISTORY VALUE EQUAL TO IDENTIFIED BUFFER HISTORY VALUE SET DISPLAY BUFFER TO IDENTIFIED BUFFER SET FLAG - PREVIOUS FRAME FOUND
LESS THAN DESIRED
570
N
CHECK FLAG - PREVIOUS FRAME FOUND?
Y
572
N
CHECK FLAG - DECODE PAUSED WAITING FOR BUFFER SPACE?
Y
578
SCHEDULE HARDWARE DECODE PROCESS
574
RELEASE CURRENT DISPLAY BUFFER
IF STEP REVERSE COMMAND PENDING, CLEAR COMMAND AND SCHEDULE AKNOWLEDGE INTERRUPT TO HOST
576
DONE

FIG. 16C

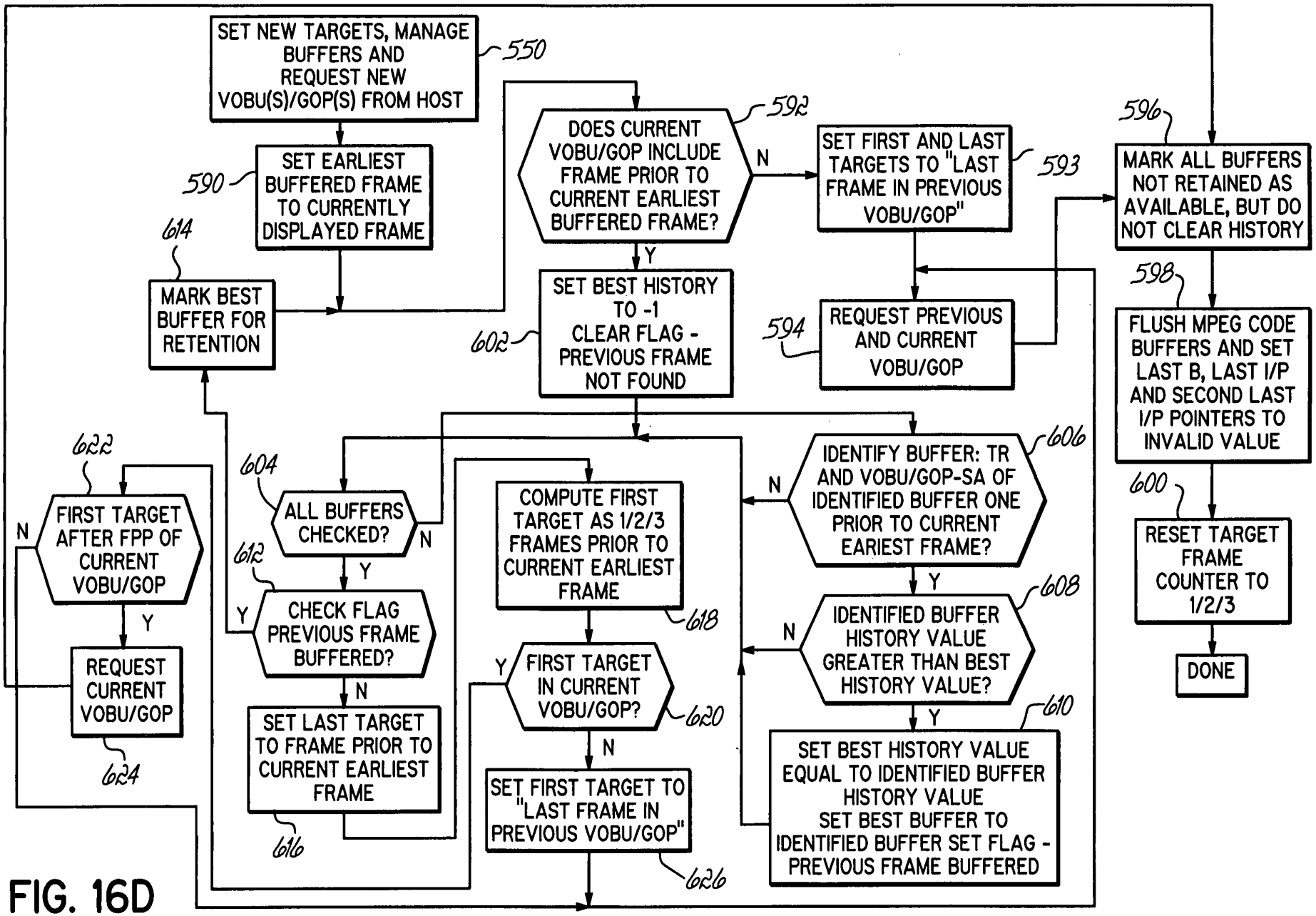
SET NEW TARGETS, MANAGE BUFFERS AND REQUEST NEW VOBU(S)/GOP(S) FROM HOST
550
SET EARLIEST BUFFERED FRAME TO CURRENTLY DISPLAYED FRAME
590
MARK BEST BUFFER FOR RETENTION
614
DOES CURRENT VOBU/GOP INCLUDE FRAME PRIOR TO CURRENT EARLIEST BUFFERED FRAME?
592
N
Y
SET FIRST AND LAST TARGETS TO "LAST FRAME IN PREVIOUS VOBU/GOP"
593
SET BEST HISTORY TO -1 CLEAR FLAG - PREVIOUS FRAME NOT FOUND
602
REQUEST PREVIOUS AND CURRENT VOBU/GOP
594
MARK ALL BUFFERS NOT RETAINED AS AVAILABLE, BUT DO NOT CLEAR HISTORY
596
FLUSH MPEG CODE BUFFERS AND SET LAST B, LAST I/P AND SECOND LAST I/P POINTERS TO INVALID VALUE
598
RESET TARGET FRAME COUNTER TO 1/2/3
600
DONE
IDENTIFY BUFFER: TR AND VOBU/GOP-SA OF IDENTIFIED BUFFER ONE PRIOR TO CURRENT EARIEST FRAME?
606
IDENTIFIED BUFFER HISTORY VALUE GREATER THAN BEST HISTORY VALUE?
608
SET BEST HISTORY VALUE EQUAL TO IDENTIFIED BUFFER HISTORY VALUE SET BEST BUFFER TO IDENTIFIED BUFFER SET FLAG - PREVIOUS FRAME BUFFERED
610
COMPUTE FIRST TARGET AS 1/2/3 FRAMES PRIOR TO CURRENT EARLIEST FRAME
618
FIRST TARGET IN CURRENT VOBU/GOP?
620
SET FIRST TARGET TO "LAST FRAME IN PREVIOUS VOBU/GOP"
626
ALL BUFFERS CHECKED?
604
CHECK FLAG PREVIOUS FRAME BUFFERED?
612
SET LAST TARGET TO FRAME PRIOR TO CURRENT EARLIEST FRAME
616
FIRST TARGET AFTER FPP OF CURRENT VOBU/GOP
622
REQUEST CURRENT VOBU/GOP
624

FIG. 16D

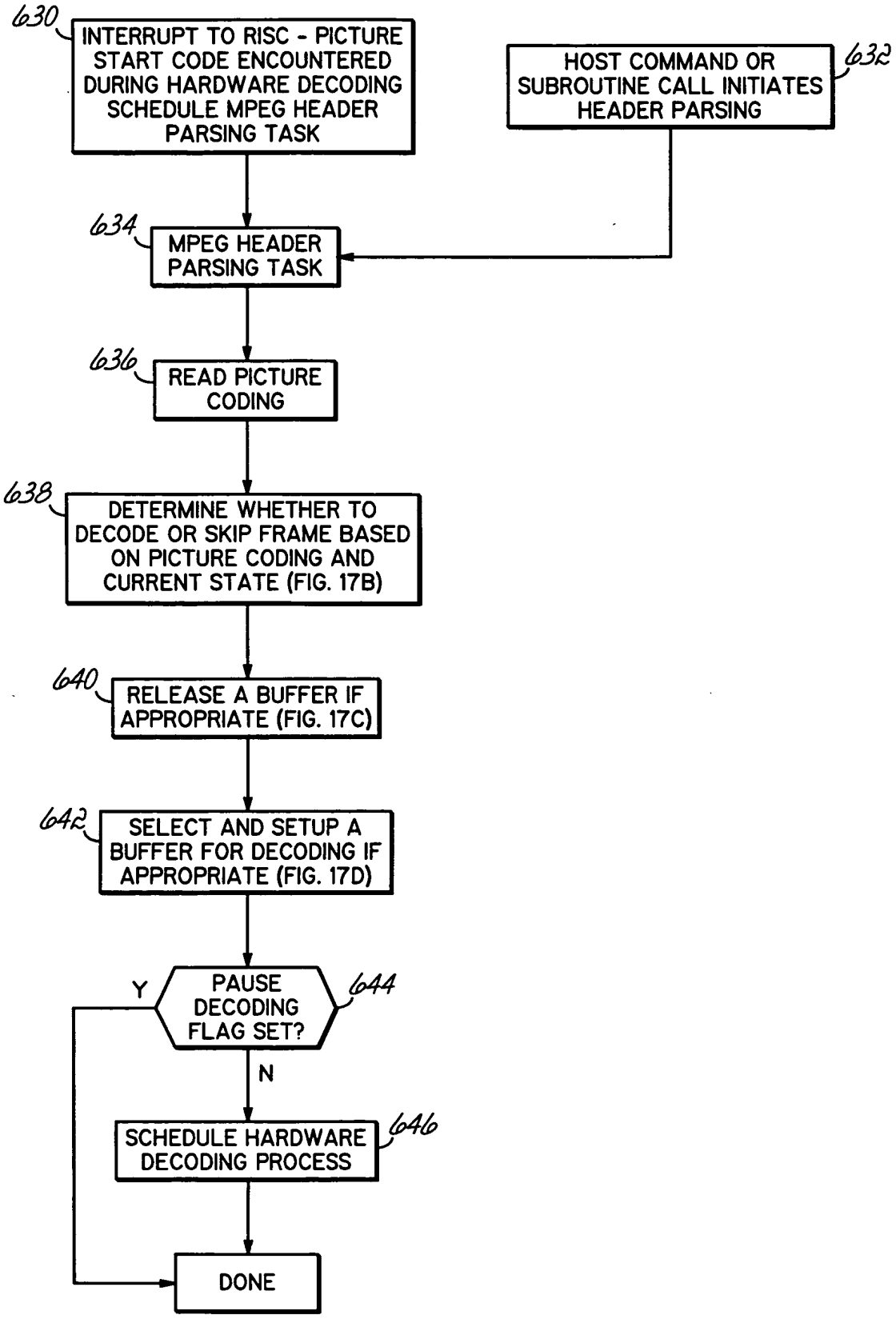
630
INTERRUPT TO RISC - PICTURE START CODE ENCOUNTERED DURING HARDWARE DECODING SCHEDULE MPEG HEADER PARSING TASK
632
HOST COMMAND OR SUBROUTINE CALL INITIATES HEADER PARSING
634
MPEG HEADER PARSING TASK
636
READ PICTURE CODING
638
DETERMINE WHETHER TO DECODE OR SKIP FRAME BASED ON PICTURE CODING AND CURRENT STATE (FIG. 17B)
640
RELEASE A BUFFER IF APPROPRIATE (FIG. 17C)
642
SELECT AND SETUP A BUFFER FOR DECODING IF APPROPRIATE (FIG. 17D)
Y
PAUSE DECODING FLAG SET?
644
N
SCHEDULE HARDWARE DECODING PROCESS
646
DONE

FIG. 17A

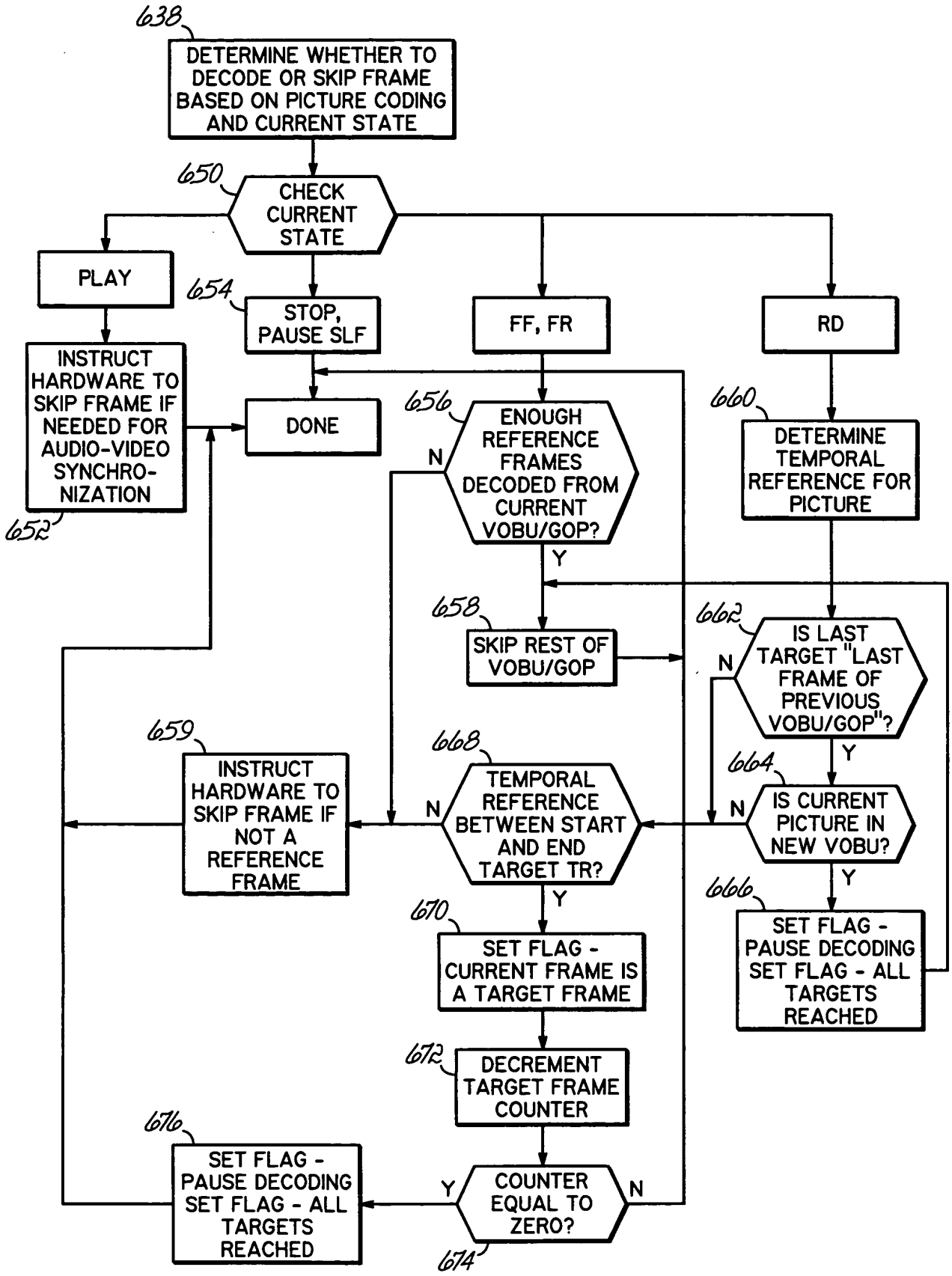
638
DETERMINE WHETHER TO DECODE OR SKIP FRAME BASED ON PICTURE CODING AND CURRENT STATE
650
CHECK CURRENT STATE
PLAY
654
STOP, PAUSE SLF
FF, FR
RD
INSTRUCT HARDWARE TO SKIP FRAME IF NEEDED FOR AUDIO-VIDEO SYNCHRO-NIZATION
652
DONE
656
ENOUGH REFERENCE FRAMES DECODED FROM CURRENT VOBU/GOP?
N
Y
660
DETERMINE TEMPORAL REFERENCE FOR PICTURE
658
SKIP REST OF VOBU/GOP
662
IS LAST TARGET "LAST FRAME OF PREVIOUS VOBU/GOP"?
N
Y
659
INSTRUCT HARDWARE TO SKIP FRAME IF NOT A REFERENCE FRAME
668
TEMPORAL REFERENCE BETWEEN START AND END TARGET TR?
N
Y
664
IS CURRENT PICTURE IN NEW VOBU?
N
Y
666
SET FLAG - PAUSE DECODING SET FLAG - ALL TARGETS REACHED
670
SET FLAG - CURRENT FRAME IS A TARGET FRAME
672
DECREMENT TARGET FRAME COUNTER
676
SET FLAG - PAUSE DECODING SET FLAG - ALL TARGETS REACHED
COUNTER EQUAL TO ZERO?
Y
N
674

FIG. 17B

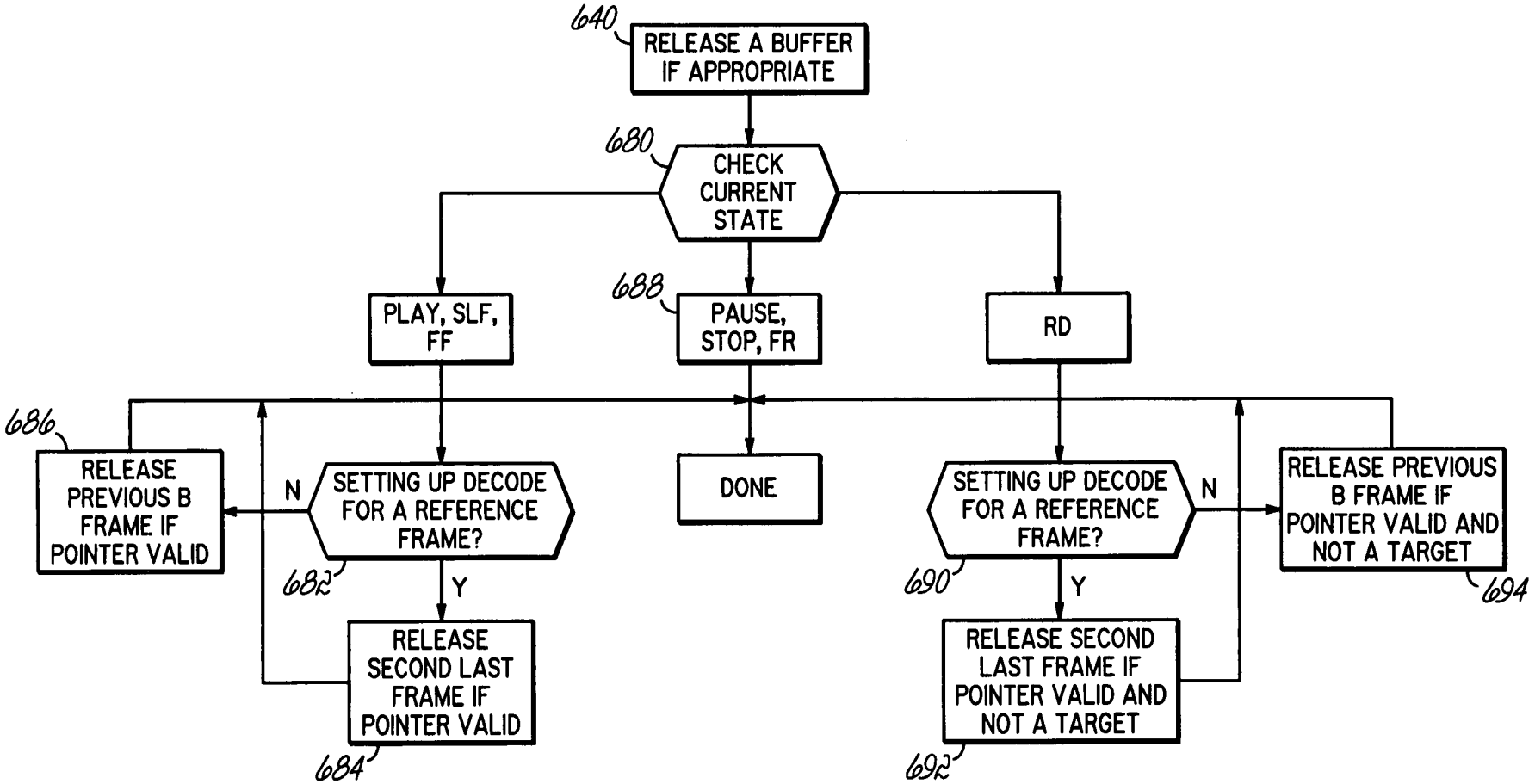
640
RELEASE A BUFFER IF APPROPRIATE
680
CHECK CURRENT STATE
PLAY, SLF, FF
688
PAUSE, STOP, FR
RD
686
RELEASE PREVIOUS B FRAME IF POINTER VALID
N
SETTING UP DECODE FOR A REFERENCE FRAME?
682
Y
RELEASE SECOND LAST FRAME IF POINTER VALID
684
DONE
SETTING UP DECODE FOR A REFERENCE FRAME?
690
N
Y
RELEASE PREVIOUS B FRAME IF POINTER VALID AND NOT A TARGET
694
RELEASE SECOND LAST FRAME IF POINTER VALID AND NOT A TARGET
692

FIG. 17C

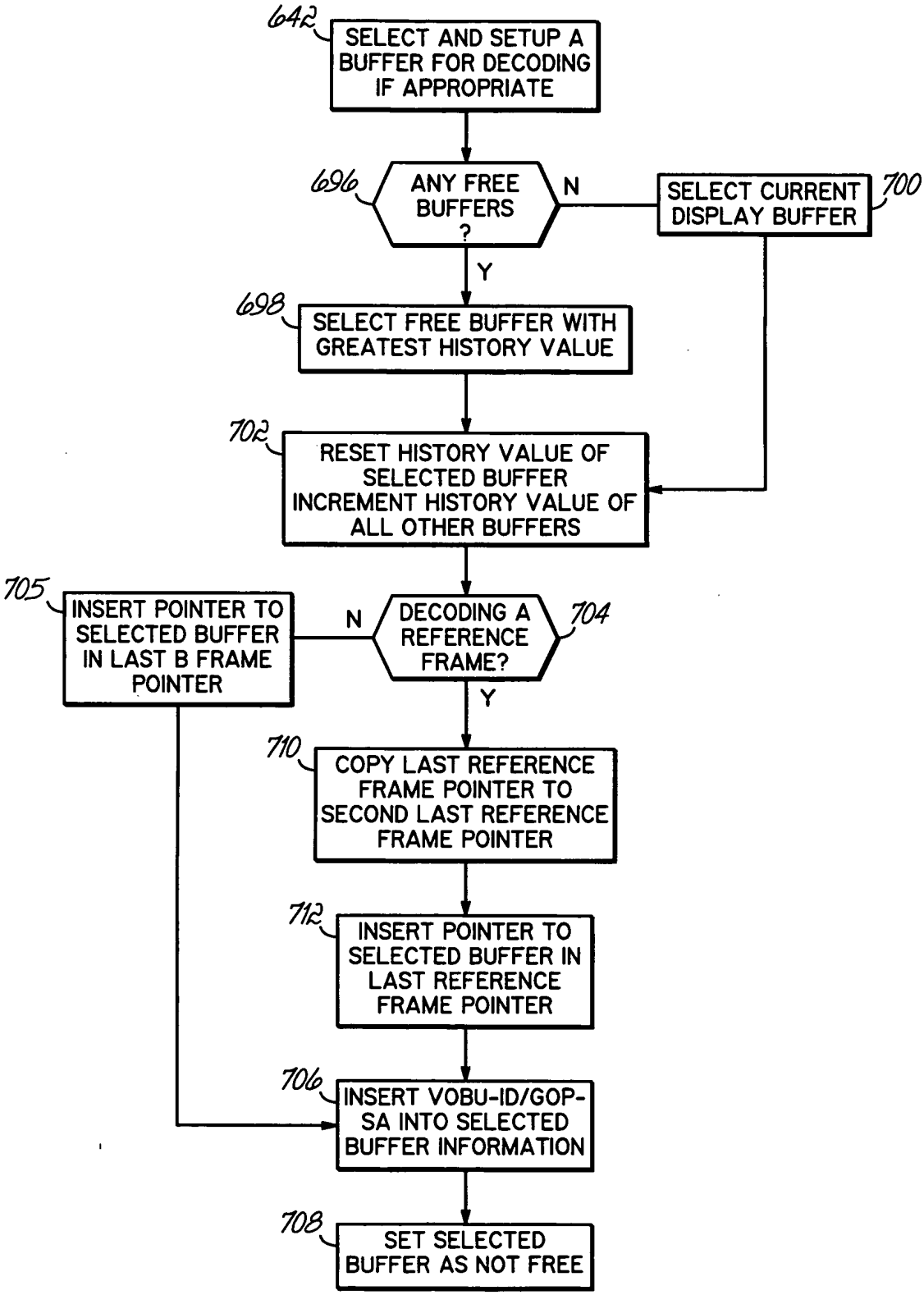
642
SELECT AND SETUP A BUFFER FOR DECODING IF APPROPRIATE
696
ANY FREE BUFFERS ?
N
SELECT CURRENT DISPLAY BUFFER
700
Y
698
SELECT FREE BUFFER WITH GREATEST HISTORY VALUE
702
RESET HISTORY VALUE OF SELECTED BUFFER INCREMENT HISTORY VALUE OF ALL OTHER BUFFERS
705
INSERT POINTER TO SELECTED BUFFER IN LAST B FRAME POINTER
N
DECODING A REFERENCE FRAME?
704
Y
710
COPY LAST REFERENCE FRAME POINTER TO SECOND LAST REFERENCE FRAME POINTER
712
INSERT POINTER TO SELECTED BUFFER IN LAST REFERENCE FRAME POINTER
706
INSERT VOBU-ID/GOP-SA INTO SELECTED BUFFER INFORMATION
708
SET SELECTED BUFFER AS NOT FREE

FIG. 17D

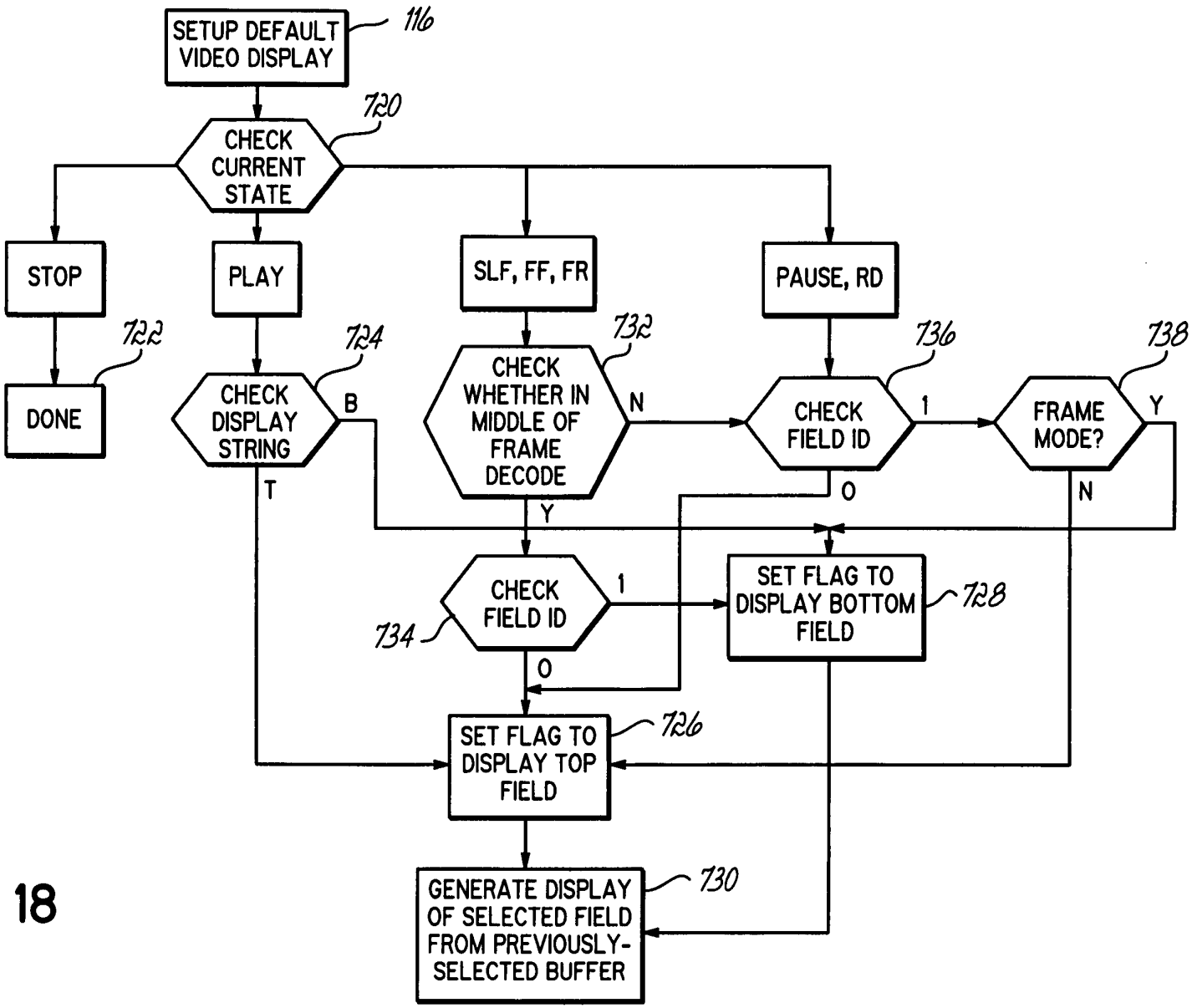
SETUP DEFAULT VIDEO DISPLAY
116
CHECK CURRENT STATE
720
STOP
PLAY
SLF, FF, FR
PAUSE, RD
722
DONE
724
CHECK DISPLAY STRING
B
T
732
CHECK WHETHER IN MIDDLE OF FRAME DECODE
N
Y
736
CHECK FIELD ID
1
0
738
FRAME MODE?
Y
N
CHECK FIELD ID
734
1
0
SET FLAG TO DISPLAY BOTTOM FIELD
728
SET FLAG TO DISPLAY TOP FIELD
726
GENERATE DISPLAY OF SELECTED FIELD FROM PREVIOUSLY-SELECTED BUFFER
730

FIG. 18